REPORT

OF THE

Committee on Petroleum

California State Council of Defense

JULY 7, 1917

CALIFORNIA STATE PRINTING OFFICE
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1917

31469

COMMITTEE

MAX THELEN, Chairman

ELIOT BLACKWELDER

D. M. FOLSOM

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CHAPTER I.

LETTER OF TRANSMITTAL.

SAN FRANCISCO, CALIFORNIA, July 7, 1917.

To His Excellency, WM. D. STEPHENS, *Governor of California.*

DEAR SIR: We submit herewith for your consideration the report of the Committee on Petroleum of the State Council of Defense.

This report is presented to you in accordance with request contained in your letter of May 9, 1917, to the chairman of the committee, reading as follows:

> May 9, 1917.
>
> MY DEAR MR. THELEN:
>
> Permit me to express my appreciation of your acceptance of the important responsibility of chairman of the Committee of the State Council of Defense on Petroleum Oil Production.
>
> The field of inquiry of your committee, as indicated by the Committee on Scientific Research, was to obtain the facts relating to production, distribution and utilization of petroleum, and to make recommendations, (1) as to measures to be taken to meet any emergency arising from the present state of war; and (2) the increased production and highest utilization of the petroleum resources of this state as an integral part of those of the United States, having regard to both industrial development and the needs of the national government.
>
> As the matter is one of urgent interest to the state and nation, I would appreciate early effort on behalf of yourself and colleagues and as prompt a report as possible to me of the result of your findings.
>
> Sincerely yours,
>
> WM. D. STEPHENS,
>
> Governor.

In response to the request contained in your letter, we have used every effort to present to you, as promptly as possible, a comprehensive and accurate report on the California petroleum situation. We have inspected all the petroleum fields of the state. We have conferred in person or by correspondence with officials of the federal government both here and in Washington, with the Committee on Petroleum of the National Council of Defense, with the California State Mining Bureau and the State Oil and Gas Supervisor, with all the leading oil companies of the state and with producers and consumers in general. From all the oil companies of the state, small as well as large, we have secured

valuable data. We have taken advantage of every source of information which seemed available in the limited time at our disposal, to the end that the facts might be reported to you fully, accurately and fairly together with such recommendations as might seem best fitted to meet the situation.

We present our report in twelve chapters as follows:

CHAPTER I. Letter of Transmittal.

CHAPTER II. World Petroleum Situation.

A review of the world petroleum situation, with a reference to the part played therein by the United States and by the state of California.

CHAPTER III. California Petroleum Fields.

A description of the California petroleum fields with the characteristics and productivity of each field; a statement of the withdrawals and restorations of California petroleum lands, including Naval Reserves Nos. 1 and 2; a reference to the principal legislation, federal and state, affecting the production of California petroleum; and a review of the litigation with the federal government affecting California petroleum lands including a reference to such cases as have been decided and reported.

CHAPTER IV. Production of California Petroleum.

An analysis and review of the past and present production of petroleum in California, as a whole and by fields.

CHAPTER V. Storage of California Petroleum.

An analysis and review of the field and other storage of petroleum in California and the amount of storage at present available.

CHAPTER VI. Transportation of California Petroleum.

An analysis and review of the transportation situation affecting California petroleum and its products with a reference to the availability and efficiency of the instrumentalities of transportation.

CHAPTER VII. Refining of California Petroleum.

A study of the processes of the California petroleum refineries, including a reference to improved processes of refining.

CHAPTER VIII. Utilization of California Petroleum and Products.

An analysis and review of the various uses to which California petroleum and its products are devoted with a reference to the extent and locality of such uses.

CHAPTER IX. General Review—Production and Consumption.

A summary of the facts of present production and consumption of California petroleum with a reference to anticipated production and consumption under present tendencies.

CHAPTER X. Production—Maintenance and Increase.

An analysis of the factors which affect the maintenance and increase in the production of California petroleum with a special reference to the material, the labor and the lands necessary for increased production, and the time in which such increase may be obtained.

CHAPTER XI. Conservation.

A study of the possibility of conserving California petroleum and its products by the elimination of field losses, the higher use of petroleum and its products, and the substitution of other forms of fuel or power, including Mexican petroleum, coal, powdered coal, hydroelectric energy and natural gas.

CHAPTER XII. Conclusions and Recommendations.

The committee's conclusions with reference to the salient facts of the California petroleum industry and its recommendations in connection therewith.

We respectfully direct your attention particularly to Chapter XII, in which chapter we state our conclusions and recommendations. As you will observe, we make recommendations on the following subjects:

1. Increased production.
2. Decreased consumption.
3. Presentation of facts to federal government.
4. Oil well material.
5. Labor.
6. Lands in litigation where no receiver.
7. Lands in litigation in possession of receiver.
8. Legislation to open petroleum lands.
9. Transportation.
10. Ultimate conservation.

The committee is under obligations to many companies and persons who have supplied data and rendered other assistance in our work.

All the oil companies and oil well supply houses in the state and their officers have responded promptly and fully to our requests for information and for other assistance. The local officials of the Department of Justice, particularly Mr. E. J. Justice, special assistant to the Attorney General; Mr. Frank Hall, special assistant; Mr. Howard M. Payne, federal receiver, and Mr. A. G. Nichols have been very helpful in supplying information and suggestions.

The committee is under particular obligation to Mr. R. P. McLaughlin, State Oil and Gas Supervisor, who prepared a special report on the subject of petroleum lands which are available for increased production; to Mr. J. F. McMahon and associates, who prepared a special report on the natural gas situation; and to Mr. H. F. Jackson and associates

of the Pacific coast section of the National Electric Light Association, who prepared a special report on the availability of hydroelectric energy in California.

Hon. Josephus Daniels, Secretary of the Navy; Hon. Franklin K. Lane, Secretary of the Interior; Hon. Newton D. Baker, Secretary of War; Hon. J. Arthur Elston, congressman from California; Mr. A. C. Bedford, chairman of the Committee on Petroleum of the National Council of Defense; Mr. Van H. Manning, director of the Bureau of Mines; Mr. C. Naramore, chief petroleum technologist of the Bureau of Mines; Mr. E. L. Doheny, chairman of the Committee on Oil of the California State Council of Defense; Prof. John C. Merriam, acting chairman of the Committee on Scientific Research of the California State Council of Defense; Prof. Bailey Willis of Stanford University; Mr. William Sproule, president Southern Pacific Company; Mr. A. G. Wells, general manager, Atchison, Topeka and Santa Fe Railway Company, coast lines; Mr. C. M. Levey, President Western Pacific Railroad Company; Mr. W. S. Palmer, president Northwestern Pacific Railroad Company; Mr. H. C. Nutt, general manager Los Angeles and Salt Lake Railroad Company; Mr. John A. Britton, vice-president and general manager Pacific Gas and Electric Company; Mr. H. H. Jones, president San Diego Consolidated Gas and Electric Company; Mr. Ralph Arnold and Mr. M. L. Requa, have all rendered assistance which has been very much appreciated by the committee.

We have availed ourselves of a number of published reports, particularly the following:

Bulletin No. 69, California State Mining Bureau—Petroleum Industry of California.

Bulletin No. 73, California State Mining Bureau—First Annual Report of State Oil and Gas Supervisor.

Bulletin No. 623, United States Geological Survey—Petroleum Withdrawals and Restorations Affecting the Public Domain.

Conservation of Oil and Gas Resources of the Americas—Ralph Arnold.

Geology and Technology of California Oil Fields—Ralph Arnold and V. R. Garfias.

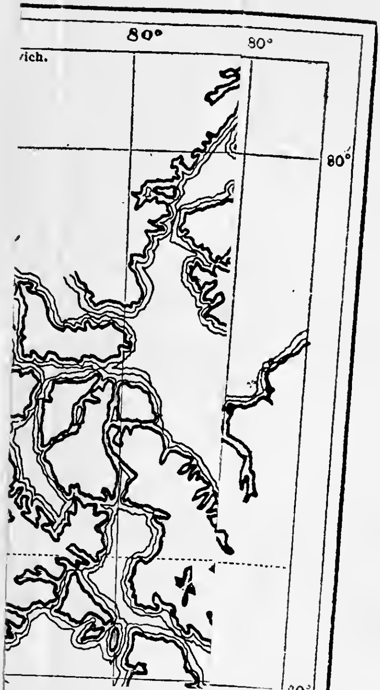
We desire to express our appreciation to the Railroad Commission of California which placed its offices and its expert and clerical force at our disposal and particularly to Mr. F. Emerson Hoar, the gas and electrical engineer of the Railroad Commission, to whose assistance in

supervising the collection and tabulation of data and in rendering every possible service we are deeply indebted.

If we can render any further service, we hope that Your Excellency will feel free to command us. We earnestly desire to render every possible assistance.

Respectfully submitted,

MAX THELEN, Chairman,
ELIOT BLACKWELDER,
DAVID M. FOLSOM,
Committee on Petroleum, State Council of Defense.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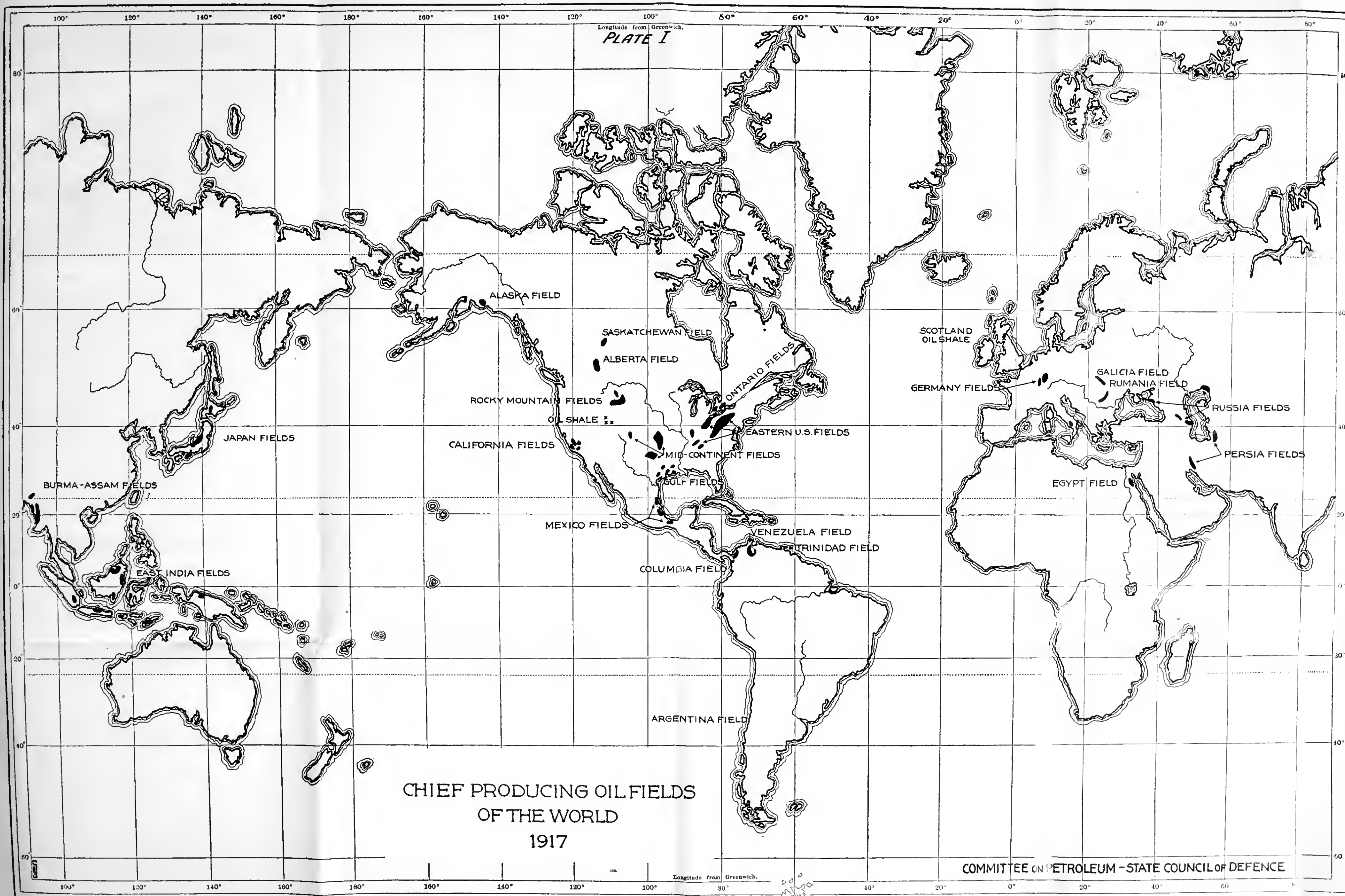
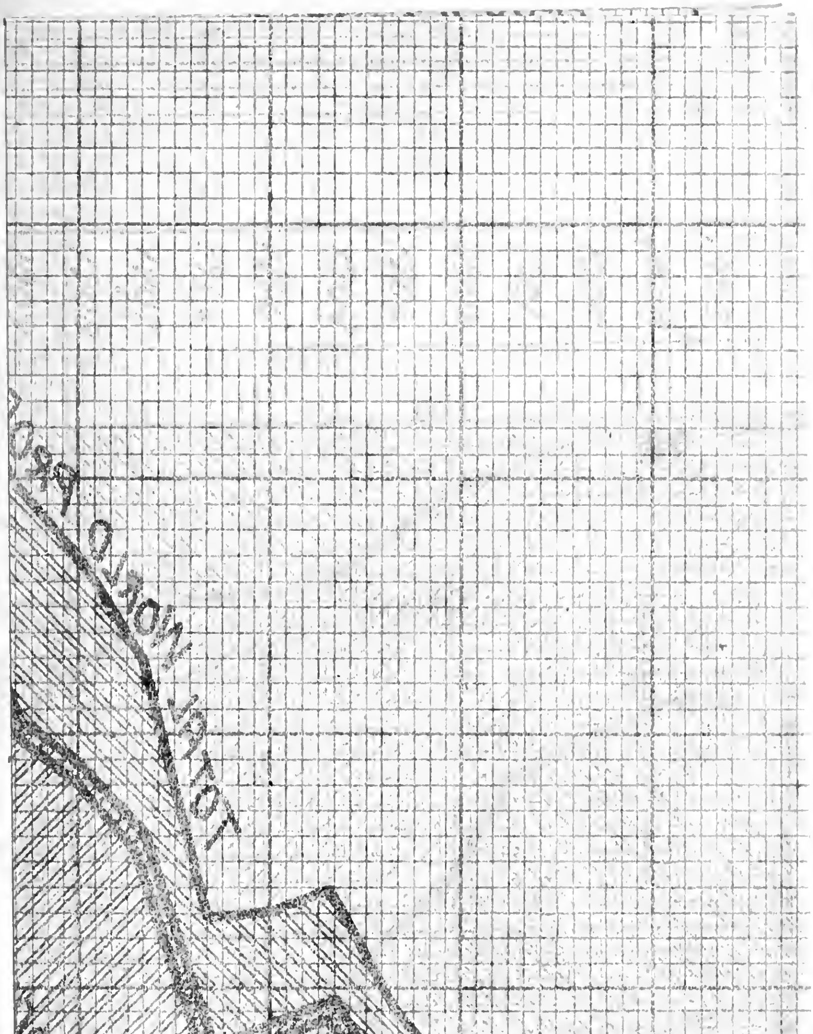


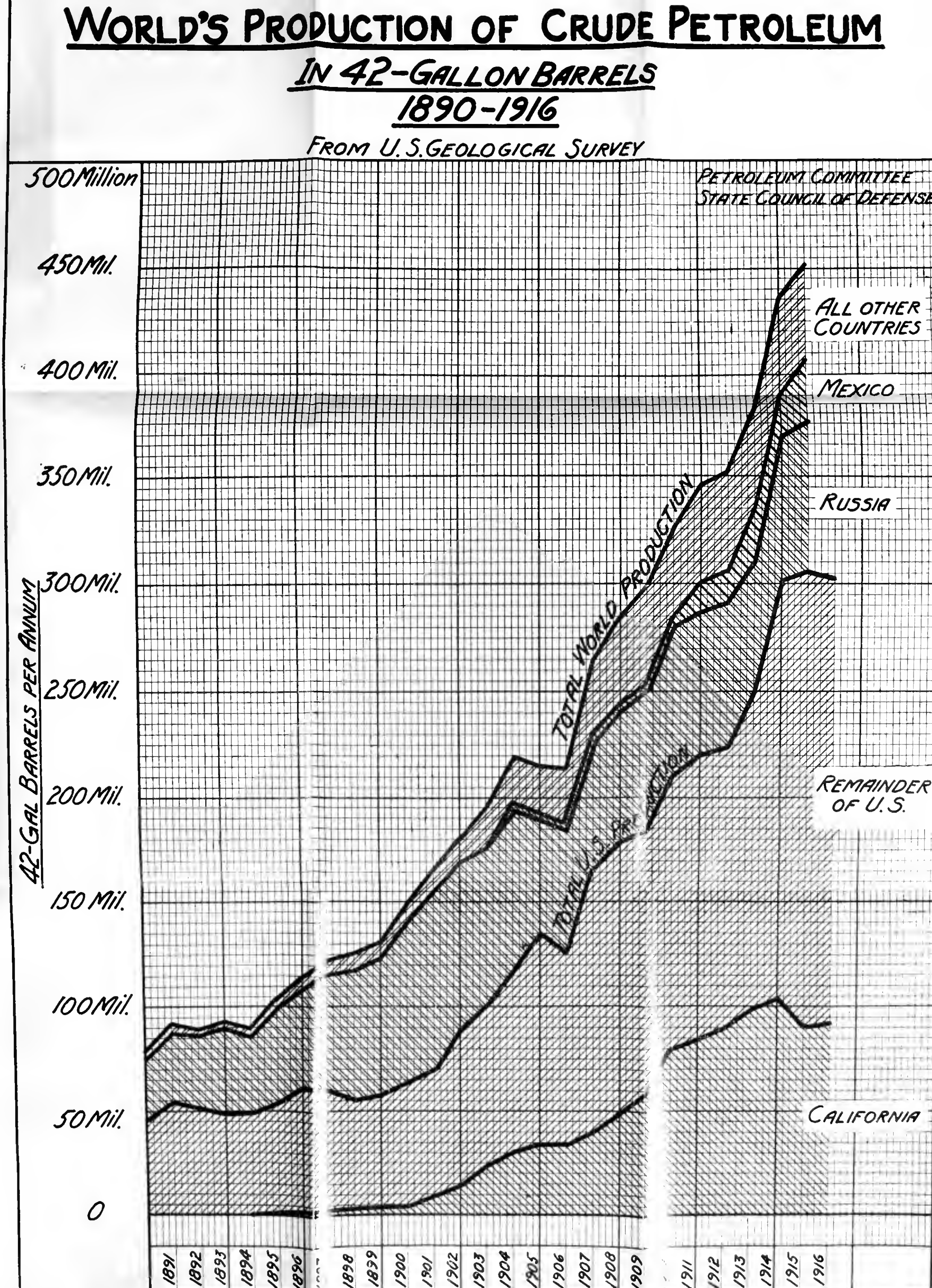
Longitude from Greenwich.
PLATE I
ALASKA FIELD
SASKATCHEWAN FIELD
ALBERTA FIELD
ROCKY MOUNTAIN FIELDS
OIL SHALE
CALIFORNIA FIELDS
ONTARIO FIELDS
EASTERN U.S. FIELDS
MID-CONTINENT FIELDS
GULF FIELDS
MEXICO FIELDS
VENEZUELA FIELD
TRINIDAD FIELD
COLUMBIA FIELD
ARGENTINA FIELD
JAPAN FIELDS
BURMA-ASSAM FIELDS
EAST INDIA FIELDS
SCOTLAND
OIL SHALE
GERMANY FIELDS
GALICIA FIELD
RUMANIA FIELD
RUSSIA FIELDS
PERSIA FIELDS
EGYPT FIELD
CHIEF PRODUCING OIL FIELDS
OF THE WORLD
1917
COMMITTEE ON PETROLEUM - STATE COUNCIL OF DEFENCE
Longitude from Greenwich.

CHAPTER II.



taly	15	39,548	.01
thers	16	[3]10,000	
Totals		427,695,317	100.00

[1]Marketed production. [2]Includes British Borneo. [3]Estimated. [4]Barrels of 42 gallons.


WORLD'S PRODUCTION OF CRUDE PETROLEUM
IN 42-GALLON BARRELS
1890-1916
FROM U.S. GEOLOGICAL SURVEY
PETROLEUM COMMITTEE
STATE COUNCIL OF DEFENSE
500 Million
450 Mil.
400 Mil.
350 Mil.
300 Mil.
250 Mil.
200 Mil.
150 Mil.
100 Mil.
50 Mil.
0
42-GAL BARRELS PER ANNUM
ALL OTHER COUNTRIES
MEXICO
RUSSIA
REMAINDER OF U.S.
CALIFORNIA
TOTAL WORLD PRODUCTION
TOTAL U.S. PRODUCTION
1891
1892
1893
1894
1895
1896
1898
1899
1900
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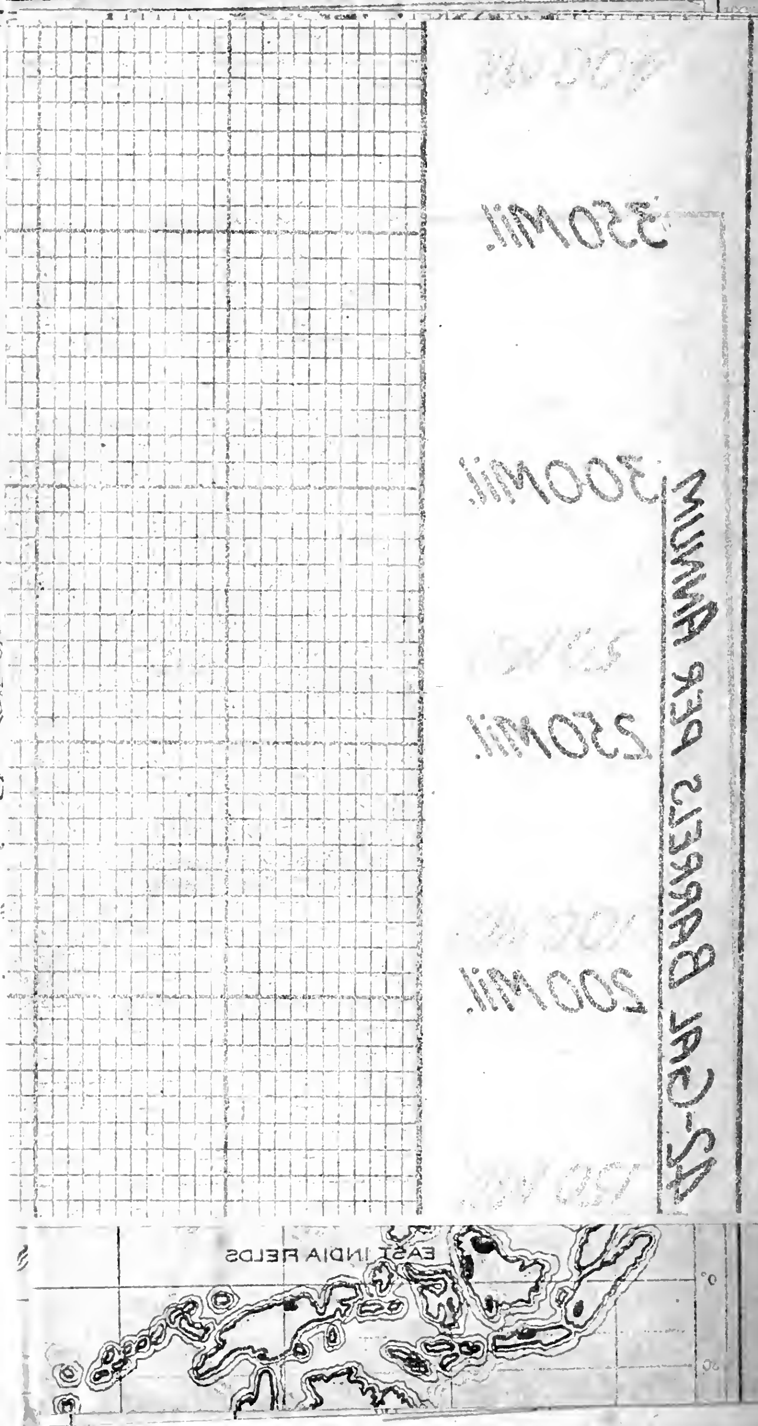


42-GAL BARRELS PER ANNUM
350Mil.
300Mil.
250Mil.
200Mil.
EAST INDIA FIELDS

CHAPTER II.

WORLD PETROLEUM SITUATION.

I. *World's Production.*

Although oil and gas have been found in small quantities in nearly all countries, the commercially productive fields are comparatively few and their areas very small. Ralph Arnold estimates that in the United States, which is the leading oil producing country, only 0.13 per cent of the land is underlain by workable oil deposits.

During the last few years, explorations for new oil fields have been carried on more energetically than ever before, even in remote and uncivilized countries. For this reason there seems to be but little hope that new oil fields of large importance will be found unless it is in Russia, or Roumania, or in certain portions of the tropical regions, where the obstacles in the way of exploration are the greatest and the expense of exploitation high.

At present, the oil supply of the world is derived largely from a few countries, as shown in Table 1 and on the map (Plate I). Changes in rank will doubtless occur. The production of the older fields may be expected to decrease, while there are possibilities of considerable expansion in others. Among the latter, the most promising are Russia, Persia, Mexico, Burma, the Dutch East Indies and Japan. It will be noted, however, that with the exception of Russia and Mexico none of the countries named below are large producers.

TABLE I.

Petroleum production of the world in 1915.

(Table compiled by U. S. Geological Survey.)

Country	Rank	Production in barrels[4]	Per cent of total
United States	1	[1]281,104,104	65.72
Russia	2	68,548,062	16.03
Mexico	3	32,910,508	7.69
Dutch East Indies[2]	4	12,386,808	2.90
Roumania	5	12,029,913	2.81
India	6	8,202,674	1.92
Galicia	7	4,158,899	.98
Japan and Formosa	8	3,118,464	.73
Peru	9	2,487,251	.58
Germany	10	995,764	.23
Trinidad	11	[3]750,000	.18
Argentine	12	516,120	.12
Egypt	13	221,768	.05
Canada	14	215,464	.05
Italy	15	39,548	.01
Others	16	[3]10,000	----------
Totals	--------	427,695,347	100.00

[1]Marketed production. [2]Includes British Borneo. [3]Estimated. [4]Barrels of 42 gallons.

It is a well-known fact that the production of each individual oil field increases and then declines. This is clearly shown on Plate II. When once drawn upon, they are comparatively short lived and the total production of a country is maintained only on the opening of new fields or pools.

It should be clearly understood that petroleum is a definitely limited resource, that much less than half (V. R. Garfias estimates one-fifth) of the existing supply can ever be recovered on a profitable basis, and that the period of abundant cheap oil on the market will surely pass within a comparatively few years. The supply of coal is much larger, and coal rather than oil will inevitably be the world fuel of the twentieth century, as it has been of the nineteenth. (See Plate IV.) All available facts indicate that the use of oil as fuel must decrease as time goes on.

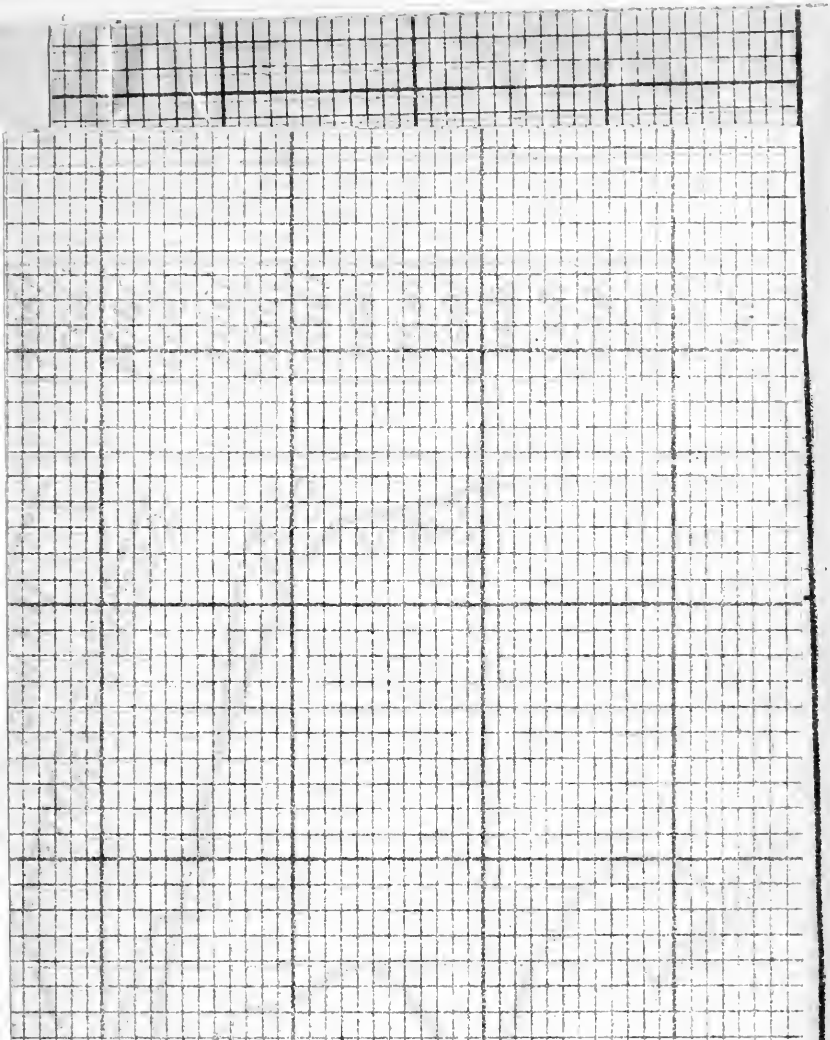
II. *Sources of Oil Tributary to the Allies.*

1. UNITED STATES.

The preeminent position of the United States at present is shown by the fact that it yields nearly twice as much petroleum as all other countries combined. Its oil fields are scattered from Pennsylvania on the east to California on the west and from Montana southward to Texas. (See Table 2.)

The fields east of the Mississippi River, largely in the drainage basin of the Ohio, have been great producers in the past, but being the first to be developed they are now on the wane. In general, these fields give light oils of paraffine base, valuable for refining purposes but of little use as fuel. Although small new fields are being discovered from time to time, even in this older district, it seems improbable that they will be sufficient to offset the general decline in production.

The Mid-Continent field, centering in Oklahoma, but with extensions in Kansas, Arkansas and northern Texas, has, within the last few years, risen from a minor position to second, and finally in 1915, to first place among the oil districts of the United States. Most of the oils are rather light and rich in gasoline and lubricants; but as nearly all have an asphalt base, the residue from the refining process is used for fuel. Although some of the individual pools in this district have been remarkably productive, they show symptoms of a more rapid decline than those of the eastern fields. Therefore it is to be expected that the production for the entire district will soon decline rather than rise, now that the region has been thoroughly surveyed and rather extensively prospected. It is very significant in this connection that although drilling in this field increased about 50 per cent in 1916 as compared with 1915, the production remained practically constant.



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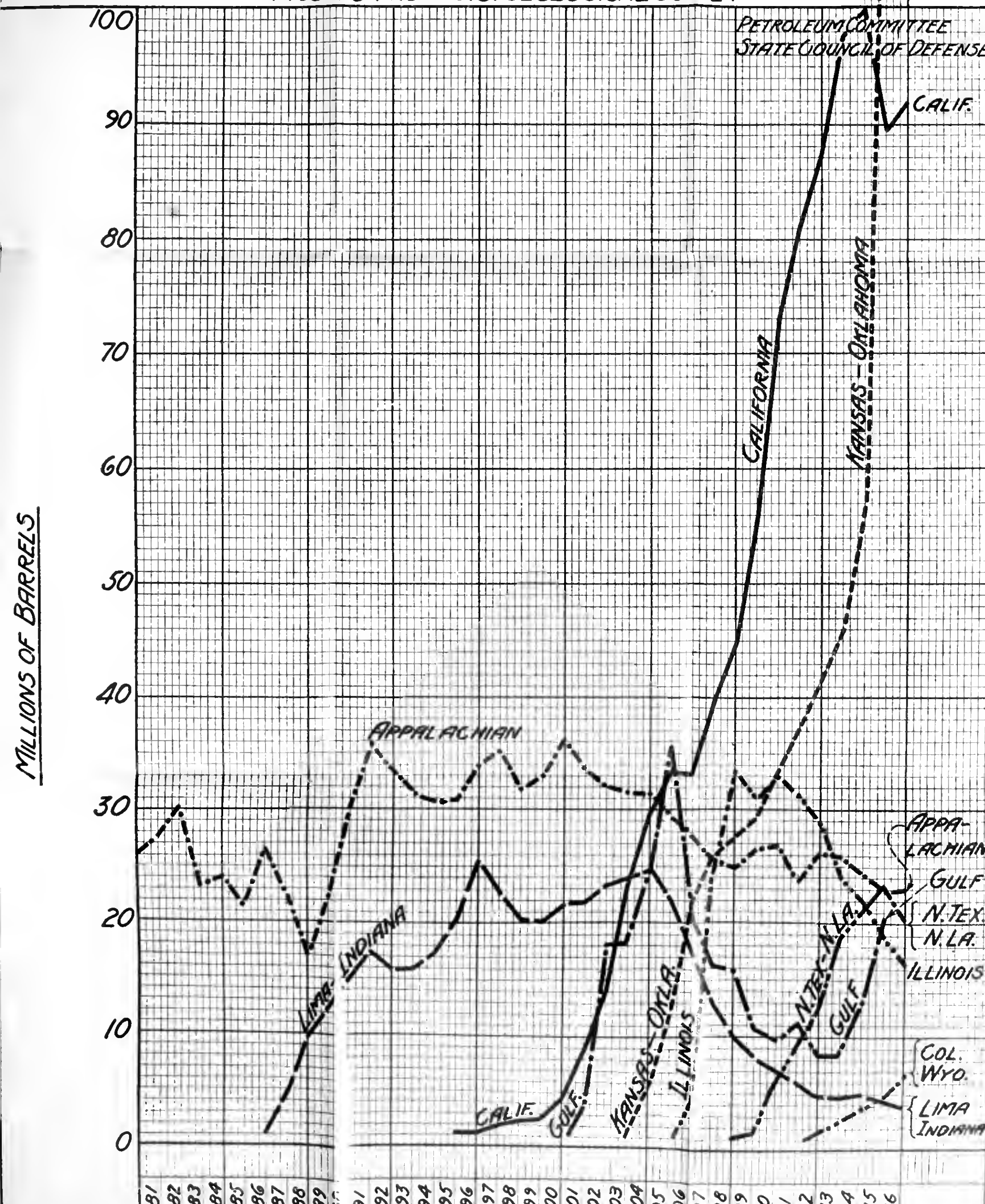
MARKETED PRODUCTION OF CRUDE PETROLEUM

UNITED STATES FIELDS 1880–1916

FIGURES FROM U.S. GEOLOGICAL SURVEY



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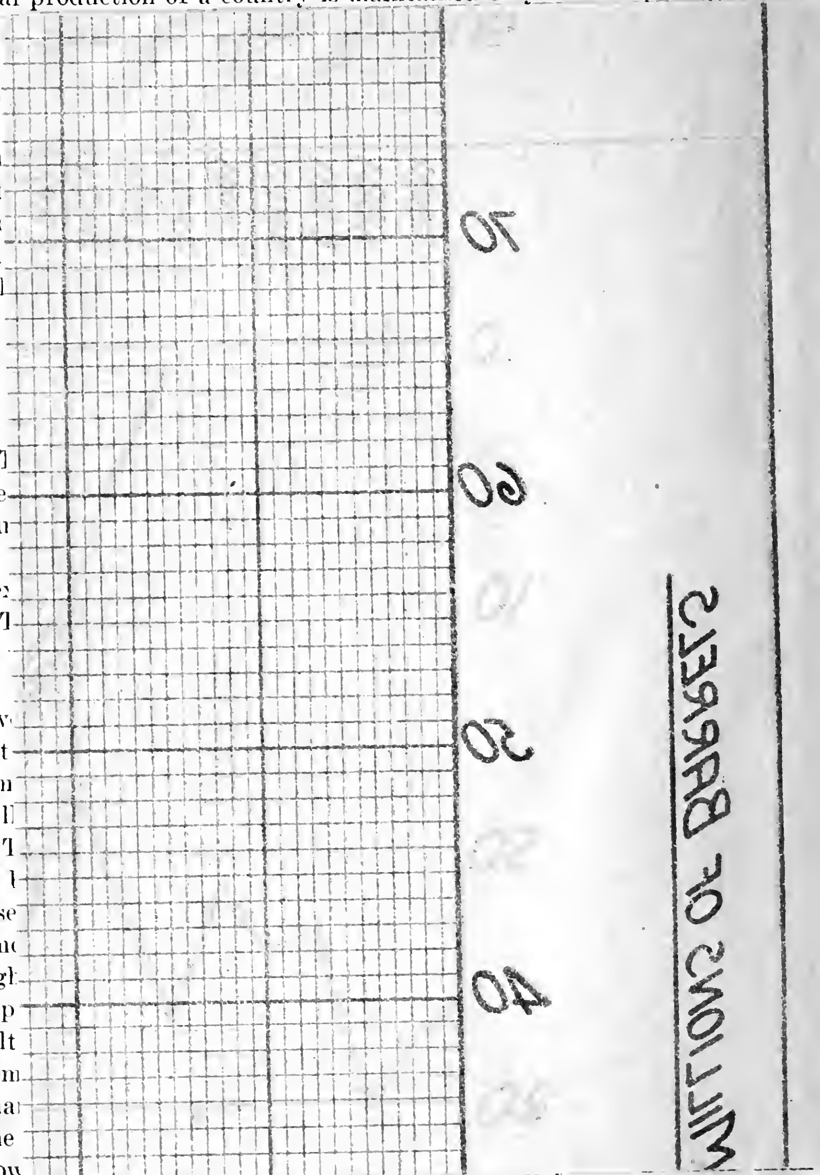

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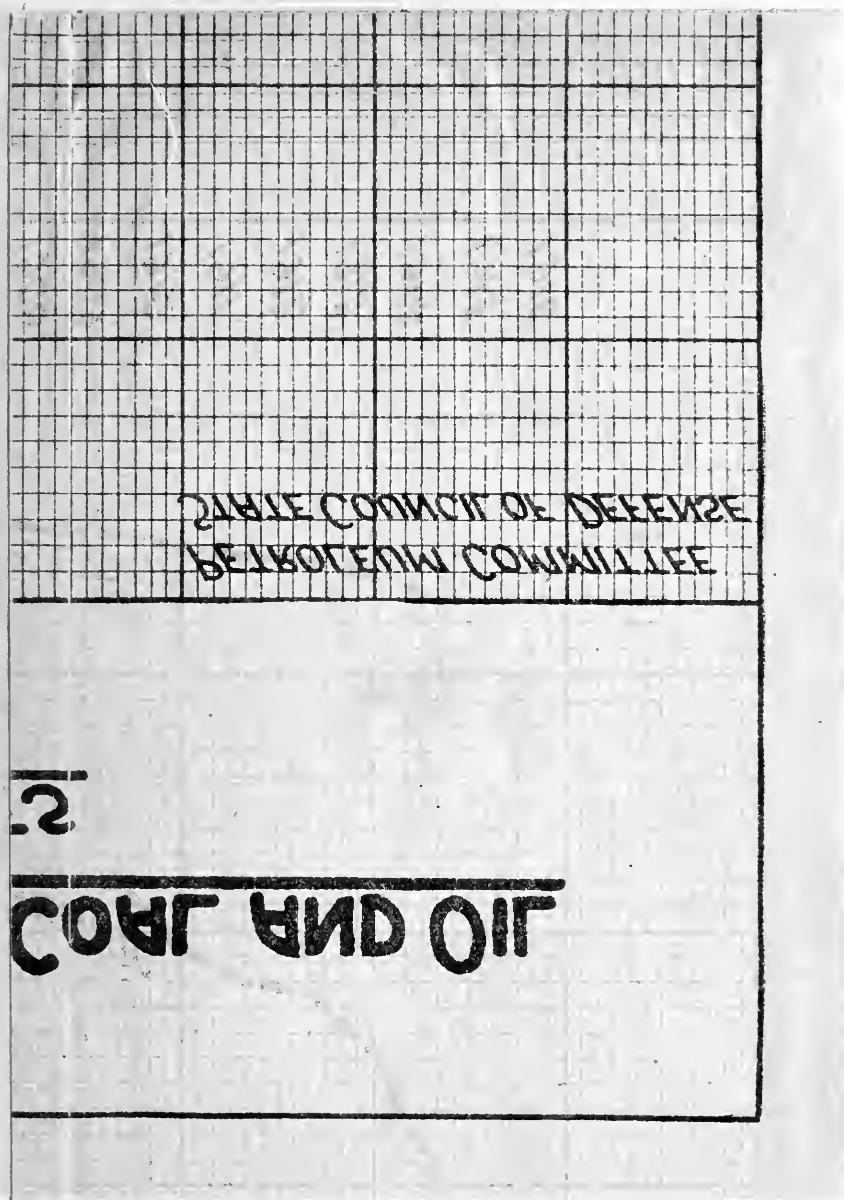

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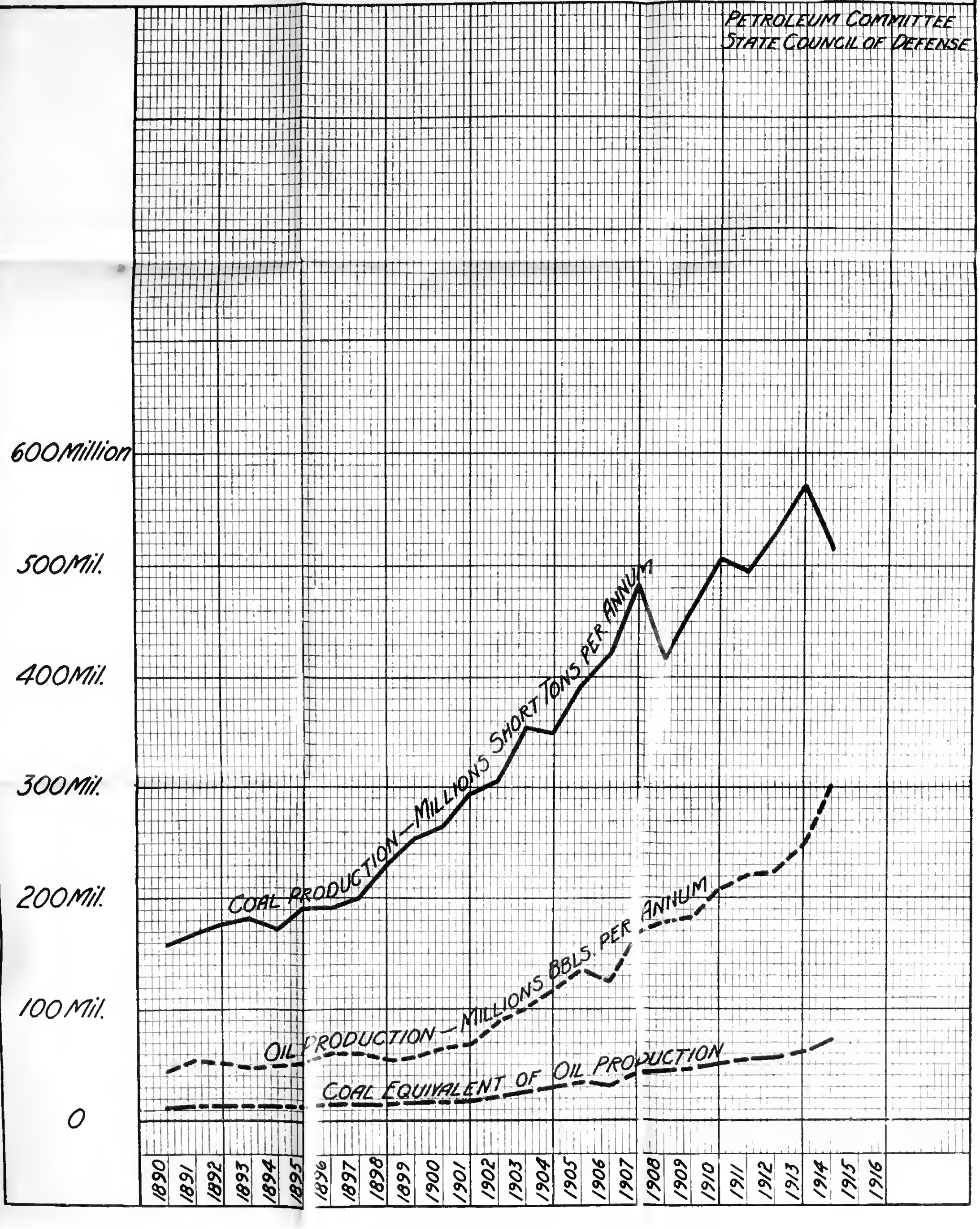
PLATE IV

COMPARATIVE PRODUCTION OF COAL AND OIL

IN THE UNITED STATES 1890-1914



It is a well known fact that the production of each individual oil

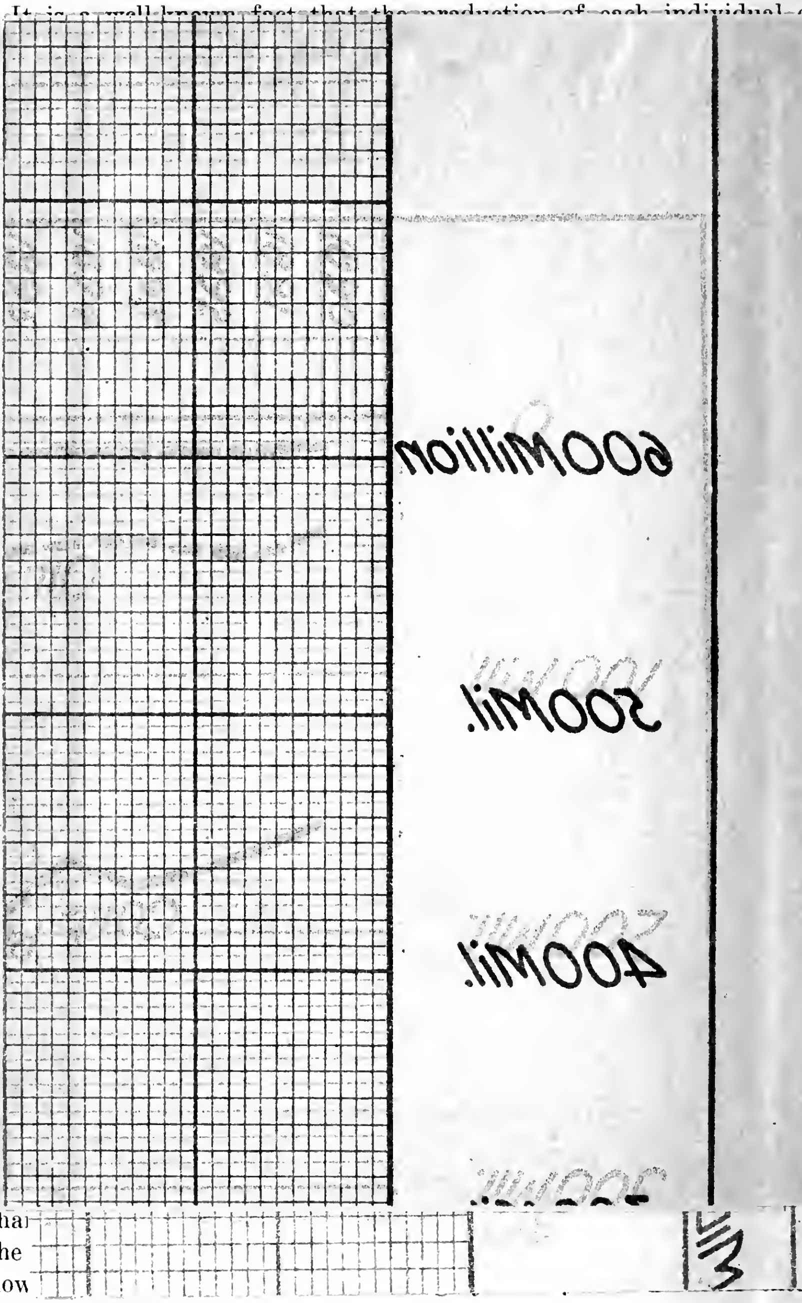


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TABLE 2.

Marketed Production of Petroleum From Principal Fields of United States.

1911–1916.

(In barrels of 42 U. S. gallons.)

Months	APPALACHIAN. 1911	1912	1913	1914	1915	1916	LIMA-INDIANA. 1911	1912	1913	1914	1915	1916
January	1,974,564	1,694,148	2,178,053	2,104,000	1,899,000	1,735,045	541,714	318,785	409,902	451,000	354,000	301,554
February	1,884,300	1,834,665	1,982,615	1,774,000	1,834,000	1,675,288	499,770	308,755	346,167	326,000	360,000	313,266
March	2,097,297	2,227,769	2,046,832	2,245,000	2,039,000	1,878,543	768,873	398,094	336,321	464,000	388,000	348,912
April	1,973,999	2,276,208	2,307,646	2,271,000	2,003,000	1,852,473	514,381	459,811	427,768	465,000	396,000	334,687
May	2,162,801	2,462,781	2,251,441	2,132,000	1,883,000	2,035,481	545,007	481,496	411,245	458,000	359,000	357,042
June	2,031,036	2,365,033	2,188,242	2,135,000	1,964,000	1,978,564	525,481	439,984	395,032	461,000	374,000	346,931
July	1,914,911	2,413,806	2,253,474	2,212,000	1,945,000	1,905,241	487,953	455,238	401,394	459,000	364,000	331,463
August	2,033,106	2,442,319	2,139,441	1,216,000	1,884,000	2,034,233	505,856	444,752	391,953	429,000	342,000	342,290
September	1,907,735	2,133,327	2,135,811	1,761,000	1,868,000	1,908,148	479,695	400,677	400,905	423,000	339,000	317,500
October	1,964,136	2,253,291	2,237,913	2,830,000	1,831,000	2,045,396	483,435	437,515	424,560	420,000	345,000	326,269
November	1,834,146	2,033,081	1,972,899	1,895,000	1,788,000	2,004,037	419,807	383,094	394,534	361,000	320,000	305,819
December	1,971,371	2,205,868	2,235,718	2,008,000	1,923,000	1,956,706	459,192	397,705	437,857	342,000	328,000	276,270
Totals	23,749,832	26,338,516	25,921,785	24,101,000	22,861,000	23,009,455	6,231,164	4,925,906	4,773,138	5,062,000	4,269,000	3,905,003

Months	KANSAS-OKLAHOMA. 1911	1912	1913	1914	1915	1916	ILLINOIS. 1911	1912	1913	1914	1915	1916
January	4,348,348	4,092,453	5,164,640	6,073,000	11,176,000	9,063,152	2,578,579	2,241,867	2,149,264	1,935,000	1,614,000	1,373,615
February	4,213,018	3,944,542	4,850,793	5,788,000	9,113,000	8,959,812	2,273,229	2,262,440	1,859,412	1,571,000	1,542,000	1,330,016
March	6,471,716	4,191,339	5,376,753	7,563,000	10,583,000	9,412,700	2,790,515	2,369,428	2,008,245	1,970,000	1,761,000	1,552,827
April	5,390,151	4,050,241	5,451,235	7,536,000	12,174,000	9,345,580	2,560,963	2,351,693	2,015,058	1,833,000	1,613,000	1,396,454
May	5,039,986	4,420,558	5,797,368	9,319,000	11,326,000	10,708,430	2,731,965	2,535,039	2,117,425	1,971,000	1,639,000	1,572,217
June	4,783,022	4,142,440	5,505,071	9,806,000	11,599,000	11,403,464	2,634,521	2,503,038	2,003,278	1,932,000	1,604,000	1,527,589
July	4,650,295	4,506,106	5,514,871	10,675,000	10,425,000	11,931,408	2,740,654	2,698,582	2,075,444	1,908,000	1,637,000	1,540,887
August	4,616,472	4,768,034	5,251,281	10,600,000	9,691,000	12,199,717	2,770,946	2,519,651	2,001,228	1,845,000	1,593,000	1,561,066
September	4,532,385	4,487,232	5,397,645	8,628,000	8,639,000	12,117,249	2,615,120	2,366,712	1,442,052	1,817,000	1,535,000	1,467,892
October	4,592,925	5,014,844	5,775,581	9,678,000	8,663,000	14,267,026	2,638,927	2,424,472	1,982,002	1,813,000	1,534,000	1,522,930
November	4,353,926	4,561,139	5,814,669	9,612,000	8,667,000	12,654,813	2,400,670	2,174,856	1,819,116	1,679,000	1,452,000	1,454,302
December	4,356,214	4,840,939	6,054,506	10,722,000	9,864,000	12,227,409	2,480,949	2,153,530	1,921,375	1,645,000	1,487,000	1,414,440
Totals	57,348,456	53,019,867	65,954,413	106,000,000	121,920,000	120,358,637	31,317,038	28,601,308	23,893,899	21,919,000	19,041,000	17,714,235

Months	NORTHERN TEXAS. 1911	1912	1913	1914	1915	1916	NORTH LOUISIANA (CADDO). 1911	1912	1913	1914	1915	1916
January	62,361	312,319	563,629	952,000	627,000	587,537	437,546	550,691	542,905	1,021,000	779,000	1,154,232
February	55,801	304,397	537,780	858,000	565,000	563,706	348,683	646,488	562,863	851,000	878,000	1,045,196
March	60,129	383,966	626,642	960,000	614,000	616,374	475,387	583,518	717,963	1,332,000	1,042,000	1,096,181
April	59,946	394,327	646,958	860,000	658,000	637,561	430,159	700,594	860,274	1,091,000	1,133,000	1,013,691
May	64,529	469,802	707,308	851,000	755,000	721,551	574,203	648,826	968,538	1,131,000	1,239,000	1,059,652
June	64,265	427,967	771,509	812,000	679,000	771,694	677,403	617,267	1,010,049	1,411,000	1,199,000	992,581
July	69,153	458,701	848,714	849,000	642,000	807,934	711,012	592,223	953,530	1,287,000	1,150,000	951,405
August	118,973	454,533	863,157	776,000	612,000	793,015	599,157	583,805	802,200	1,162,000	1,630,000	882,935
September	155,975	465,039	887,324	731,000	607,000	745,839	731,306	593,422	812,062	1,129,000	1,539,000	811,648
October	253,155	535,919	936,438	716,000	591,000	776,987	791,868	562,616	905,558	962,000	1,282,000	802,528
November	310,436	529,783	905,928	700,000	581,000	741,205	652,675	550,887	814,545	878,000	1,210,000	723,850
December	298,781	538,776	885,865	705,000	605,000	737,463	566,429	547,612	831,073	855,000	1,185,000	731,196
Totals	1,573,504	5,275,529	9,184,252	9,770,000	7,536,000	8,500,868	6,995,828	7,177,949	9,781,560	13,110,000	15,752,000	11,265,195

Months	COLORADO. 1911	1912	1913	1914	1915	1916	WYOMING. 1911	1912	1913	1914	1915	1916
January	19,007	14,848	18,758	16,696	18,282	----	----	----	----	199,862	338,069	----
February	16,299	15,310	16,093	15,563	15,758	----	----	----	----	163,148	254,930	----
March	19,537	17,171	17,301	16,436	16,317	----	----	----	----	230,389	354,381	----
April	19,466	17,711	15,443	17,986	18,024	----	----	----	----	300,249	196,841	----
May	17,259	18,008	16,152	17,905	15,027	----	----	----	----	376,207	248,088	----
June	16,317	16,298	15,919	17,804	11,022	----	----	----	----	221,491	395,364	----
July	19,508	19,168	15,933	19,934	17,322	----	----	----	----	287,310	391,182	----
August	19,570	17,503	14,543	20,553	14,599	----	----	----	----	378,251	437,165	----
September	19,882	17,553	14,908	19,829	15,907	----	----	----	----	386,643	372,956	----
October	22,792	17,593	15,186	20,645	16,696	----	----	----	----	373,629	452,991	----
November	19,924	17,119	14,417	19,888	21,056	----	----	----	----	342,885	388,540	----
December	17,365	17,770	14,143	19,534	25,435	----	----	----	----	300,011	412,022	----
Totals	226,926	206,052	188,799	222,773	208,475	190,000	*186,695	1,572,306	2,406,52[illegible]	3,560,375	4,245,525	6,300,000

*Includes Utah.

Months	GULF—†FIELD. 1911	1912	1913	1914	1915	1916	CALIFORNIA†. 1911	1912	1913	1914	1915	1916
January	1,152,291	717,938	704,900	802,209	1,190,221	----	6,566,180	7,627,258	7,582,3[illegible]	8,746,885	7,766,364	6,924,272
February	1,346,180	711,842	610,703	748,363	1,423,127	----	5,973,206	6,893,432	7,302,7[illegible]	8,693,391	6,912,331	6,481,339
March	1,357,389	781,730	876,333	1,067,969	1,468,660	----	7,089,955	7,289,498	8,184,8[illegible]	8,884,321	7,568,319	7,552,342
April	1,076,530	752,583	756,342	1,227,341	1,430,981	----	6,929,337	7,208,672	7,943,8[illegible]	8,541,030	7,341,080	7,382,909
May	1,048,598	707,766	757,767	1,256,762	1,217,599	----	7,113,146	7,333,180	8,098,1[illegible]	9,221,146	7,630,749	7,735,305
June	908,343	684,210	696,534	1,259,789	1,329,922	----	6,694,078	7,345,702	8,109,9[illegible]	9,072,000	7,458,600	7,663,549
July	880,446	713,912	676,240	1,125,014	1,558,720	----	6,937,862	7,560,748	8,573,9[illegible]	9,185,176	7,641,541	8,010,185
August	829,057	700,644	687,520	1,139,348	1,486,166	----	7,208,934	7,694,142	8,807,1[illegible]	9,112,243	7,676,954	8,043,181
September	797,824	675,053	683,939	1,101,204	1,877,680	----	7,291,254	7,581,285	8,522,2[illegible]	8,699,370	7,370,426	7,965,435
October	801,353	670,532	678,060	1,222,164	2,437,192	----	7,283,434	8,158,814	8,163,0[illegible]	8,746,712	7,642,763	8,262,111
November	707,435	684,341	671,789	1,014,491	2,823,571	----	7,210,297	7,676,176	8,197,9[illegible]	7,793,130	7,223,268	7,896,266
December	772,116	711,467	742,368	1,062,874	2,303,264	----	7,446,041	7,705,232	8,380,9[illegible]	7,775,637	7,334,381	7,935,468
Totals	11,677,562	8,545,018	8,542,491	13,117,528	20,577,103	----	83,744,024	90,074,439	97,867,1[illegible]	104,171,331	89,566,779	91,852,362

†Standard Oil Company figures. Actual well production.

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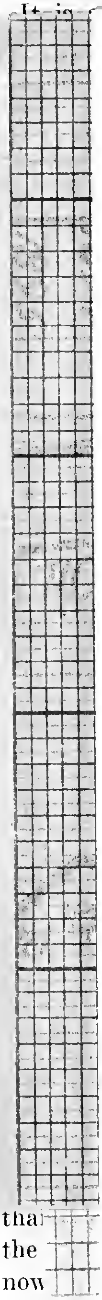

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Mr. Van H. Manning, chief of the U. S. Bureau of Mines, has recently predicted a substantial decrease in the 1917 production of Oklahoma and Kansas.

The Gulf field in Texas and Louisiana comprises a number of small scattered pools, some of which have been highly productive. Many individual gushers have given thousands of barrels per day for a short time, but on the whole their decline has been more rapid than those in other fields. The production of the entire district has fallen off during the last few years in spite of the drilling of many new wells and the finding of some new pools, which gave a temporary recovery to the production curve. The oil from this district varies from heavy asphaltic oils, chiefly useful for fuel, to light paraffine-base oils of the best refining grades.

The Rocky Mountain field, comprising Colorado, Wyoming, Utah and Montana, has been relatively unimportant until lately, but Wyoming is now the scene of the most active prospecting and its production is increasing somewhat rapidly. It still, however, falls short of the other oil regions in the United States, and the United States Bureau of Mines anticipates no further increase in 1917. The individual pools are much scattered and differ considerably in their characteristics. Some give a heavy fuel oil of asphalt base, while others are more like the light oils of the eastern fields. In addition to the petroleum deposits workable under such conditions, there are in Utah, Wyoming and Colorado enormous quantities of oil-bearing shale which yields on distillation a high-grade petroleum of paraffine base. When the price of oil shall have risen to the point (about $3.75 per barrel) where the exploitation of those shales becomes profitable, they will doubtless be used, as they are now in Scotland, but at present almost no oil is being obtained from this source.

The California field, which for several years has led all others in the United States in point of production, is described in detail in the next chapters. The production of the state has apparently reached, or almost reached, its climax. The oils are nearly all asphaltic and although gasoline and other products are derived from them by refining and otherwise, about seven-eighths of the production has been used for fuel. The possession of this fuel has been a source of great wealth to the Pacific Coast States, where coal is relatively scarce.

In the United States as a whole, the production of oil and gas has been slowly increasing up to the past year (about 300,000,000 barrels in 1916), but it is now only by the most active drilling operations that the inevitable decline is being forestalled. (See Plate III.) Meanwhile, the demand for crude oil and its refined products, such as gasoline, is rapidly increasing, and the increase has been accelerated by the

entrance of the United States into the world war. This is shown by the steady decrease in the amount of crude oil which has been stored in the various parts of the United States largely as a result of the overproduction of oil during 1914 (see Plate V).

Mr. L. M. Fanning, writing for the Oil Trade Journal, June, 1917, estimates that, for the new navy and merchant marine now planned, an abnormal consumption of 10,000,000 to 35,000,000 barrels of fuel oil alone will be required per year. There will also be a greatly increased demand for gasoline and lubricants for use in aeroplanes and motor trucks.

It is evident that with the consumption increasing and the production nearly stationary or even decreasing, the stored oil is likely to be exhausted within a short time—probably less than two years. The United States will then be confronted with a deficit of petroleum products unless it is able to greatly increase its importations from the only available source of importance—Mexico. As a partial offset to this unfavorable condition, the production of gasoline from a given amount of crude oil has been largely increased of late by improved methods of refining and by the recovery of gasoline from natural gas accompanying the oil.

2. RUSSIA.

The prolific oil fields of Russia are situated in the Caucasus region and especially on the west shore of the Caspian Sea. A new field of considerable promise has lately been opened up on the north shore of the Caspian. The many small fields in other parts of the vast empire now produce little or no oil. Most of the petroleum is of asphalt base and from medium to heavy gravity. In 1901 Russia produced more oil than any other country, not even excepting the United States, but since that time the production has decreased, not on account of the exhaustion of the supply, but mainly because of political, racial and social disturbances, which have caused widespread destruction of stocks and improvements, and have tended to discourage further development.

In 1913—the last year preceding the war—about 95 per cent of Russia's petroleum output was used in its own territory. During the war, with the closing of the outlet through the Mediterranean Sea, the export trade has doubtless ceased almost entirely. It is evident, however, that with the resumption of normal conditions and adequate protection for the oil operators after the war, Russia should be able to greatly increase her production of oil, and probably her exports of its products. It is a fair question, however, whether Russia, with its enormous population, will ever have much oil in excess of its own requirements.

3. MEXICO.

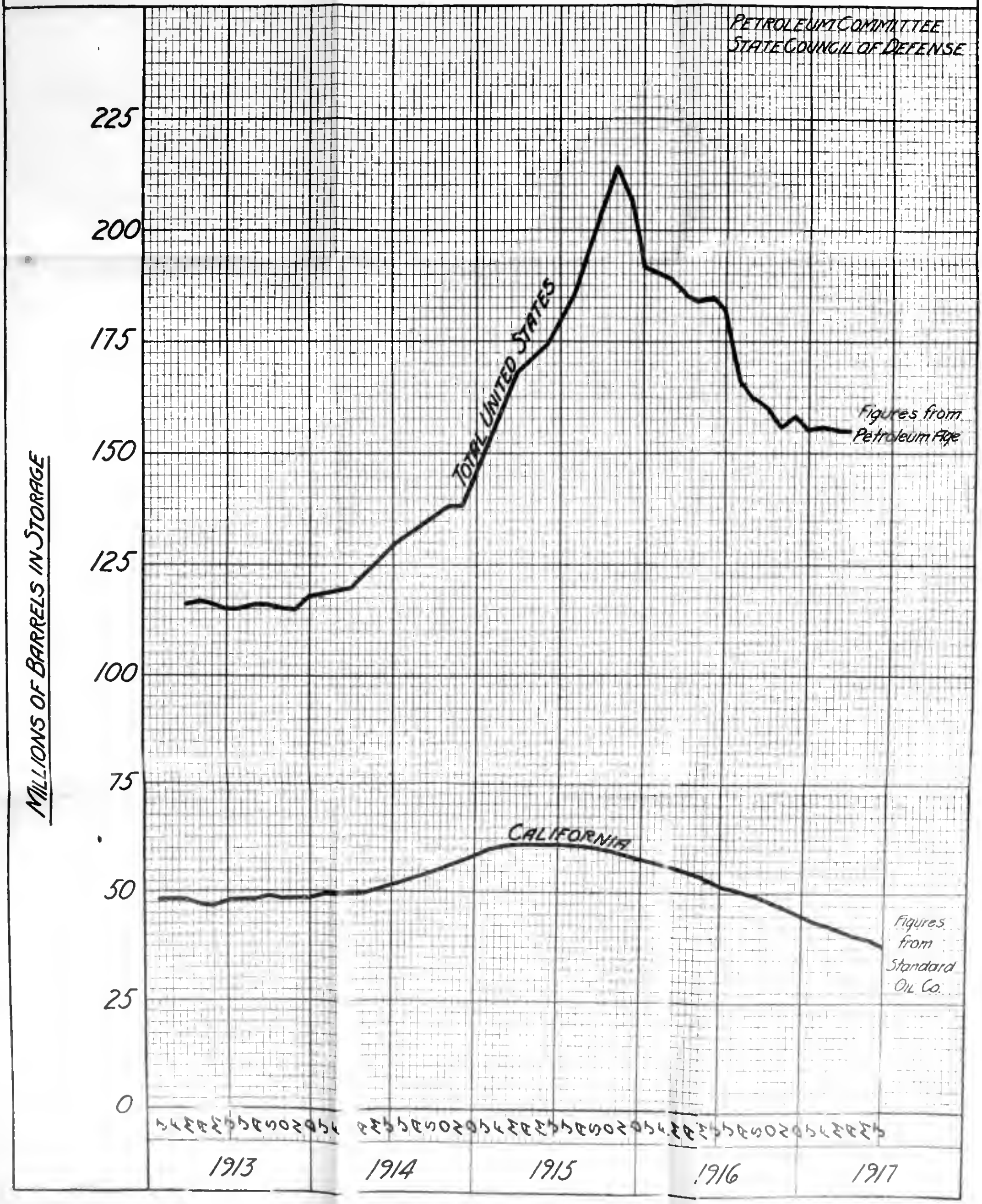
The known oil fields of Mexico are situated in the coastal plain bordering the Gulf of Mexico. Being of low gravity, the oil is used largely for fuel, but a noteworthy part is refined and the proportion of

PLATE V

CRUDE OIL IN STORAGE

IN THE UNITED STATES

1913—1917



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the steady decrease in the amount of crude o
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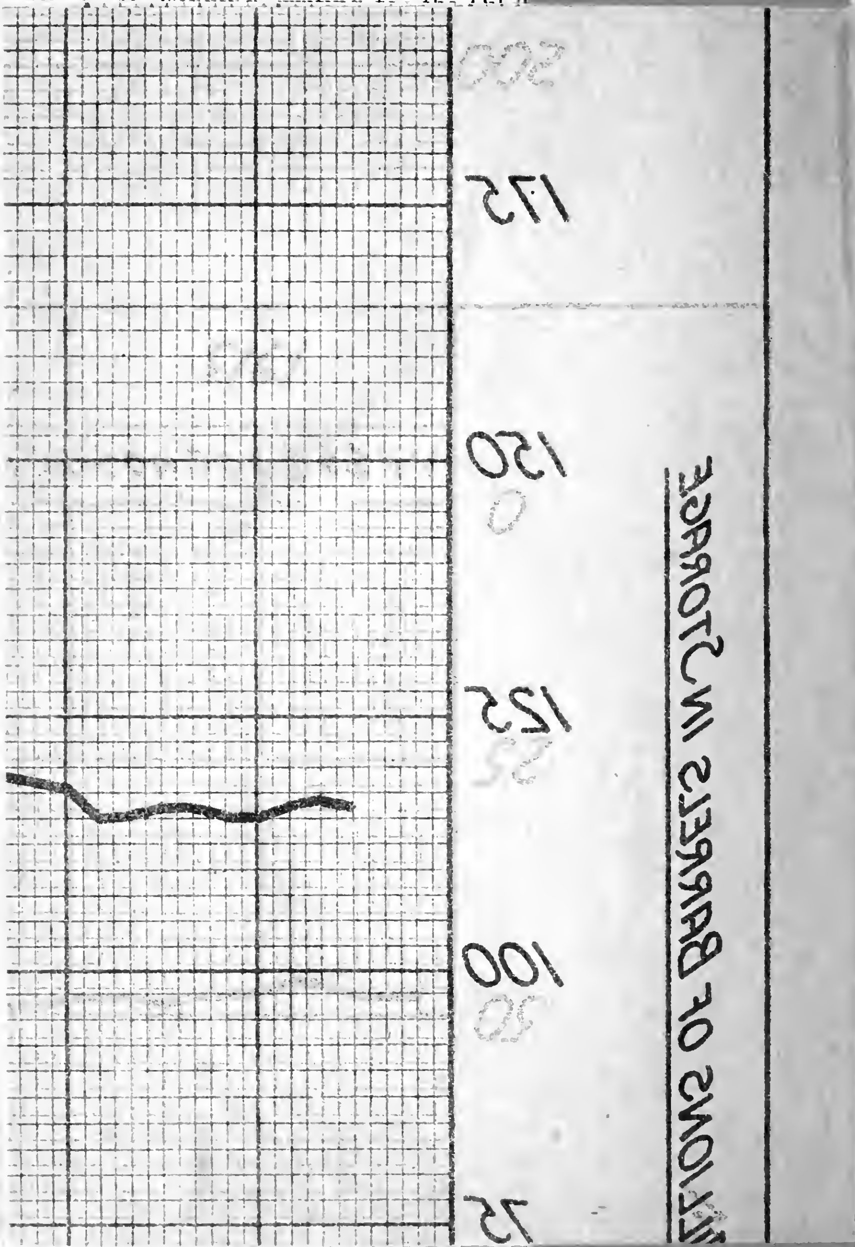


3. MEXICO.

The known oil fields of Mexico are situated in the coastal plain bordering the Gulf of Mexico. Being of low gravity, the oil is used largely for fuel, but a noteworthy part is refined and the proportion of this is increasing. According to data published by the United States Bureau of Mines, about 60 per cent of the oil in 1916 was exported to the United States, and some of the remainder to England and other European countries. An increasing quantity is being shipped through the Panama Canal to the west coast of South America, where it is now helping to relieve the necessity of continuing the exportation of fuel oil from California.

The possibilities for increased oil production in Mexico are large but uncertain. Unstable political conditions within the country and the insufficiency of transportation facilities for the products exported have held development in check within the last few years. It is certain, however, that with more active drilling and prospecting in progress under an assured economic status, and with ample steamer capacity, it would be possible to increase production greatly. The director of the United States Bureau of Mines testified before the Senate Committee on Public Lands, on June 13, 1917, that the present potential yield of the Mexican oil wells was about 1,000,000 barrels a day, or nearly 25 per cent more than that of the entire United States.

4. DUTCH EAST INDIES.

In spite of the natural obstacles to exploitation, Java, Sumatra, Borneo and certain adjacent islands have lately been furnishing a continually increasing supply of petroleum. Most of the oils are of rather high grade, with a paraffine base, and are used chiefly for refining purposes. Before the war, the products were marketed principally in the Oriental countries, but lately the supply has been so largely diverted to Europe for the use of the Allies that in 1915 England obtained more gasoline from the Indies than from the United States.

We are reliably informed that these islands contain important areas as yet unprospected and that an increasing production may be expected from them for a number of years to come. The natural difficulties of the tropics, however, will probably prevent a rapid development.

5. MINOR FIELDS.

In addition to the countries which have been mentioned, about eight or nine others, which are accessible to the Allies in the present war, produce sixteen or more million barrels of oil annually, or less than half as much as Mexico. In most cases the yield is insufficient for domestic consumption and hence the majority of these countries are importers

of petroleum products. With reference to the war they are of negligible importance. The only important exception to this seems to be Trinidad, which now exports nearly one million barrels a year, chiefly to England.

For the future, there are prospects of a considerable increase in the number of wells and in the oil produced in Japan, Persia, and, perhaps, Peru; and some other countries such as Venezuela and Colombia have recently become small producers; but there is as yet no assurance that any of these nations will ever figure largely in the petroleum industry.

III. *Sources of Oil Tributary to the Central Powers.*

1. GALICIA.

The oil wells along the north side of the Carpathian Mountains have for many years yielded rather high-grade oils of paraffine base. During the past decade the production has been declining until it reached about 7,000,000 barrels a year at the outbreak of the war. During the war, Galicia has been a battle ground, and regarding its present condition there is little definite information available. Although the Austro-Germans, in whose hands the territory largely rests at present, have doubtless tried to obtain the maximum production, it is safe to presume that much destruction has already been wrought. It seems probable that Galicia will, after the war, continue its decline as a producer of oil.

2. ROUMANIA.

The well-known Roumanian oil fields are really an extension of the Galician fields southward along the convex curve of the Carpathian foothills. The oils are varied in character, with the lighter varieties predominating. Just before the outbreak of the war Roumania was exporting about 65 per cent of the petroleum produced. The fuel oil and residues were consumed largely within Roumania, while the exports consisted chiefly of the lighter refined products, and were marketed especially in the countries of western Europe.

By their astonishingly rapid conquest of the country, the Central Powers were able to seize nearly all of the oil-producing territory. It is reported that many of the wells were not seriously damaged, but on the other hand an American engineer recently returned from Roumania states that most of the wells were plugged and cemented by their owners in such a way as to necessitate complete redrilling. It is obvious, in either event, that the Teutonic Powers are making every effort to restore the productivity of this field. It is doubtful, however, whether they can have yet more than partly succeeded. We are credibly informed that there is much productive oil land in Roumania which has not been effectively prospected, and hence some increase in production after the termination of the war may be reasonably expected.

3. MINOR FIELDS.

Relatively small quantities of petroleum are produced in Germany and Hungary, but the fields have been thoroughly tested and offer no prospects of considerable increase, but rather of the inevitable falling off of old fields.

IV. *Summary.*

So far as increase of oil production for the Allies during the war is concerned, we need consider only the United States and Mexico, with the possible addition of the Dutch East Indies and Trinidad and perhaps Venezuela. In the United States some of the oil fields are incurably on the decline, others near their climax, and still others on the ascent. As a whole, the production of oil in this country appears to have nearly or quite reached its maximum and to be just entering upon its period of decline. At present the tying up of a large acreage of oil lands in California and Wyoming by federal suits, the inadequacy of transportation facilities in Wyoming, and in many other fields the difficulty of obtaining the necessary materials for drilling, are tending to obstruct the stimulation of production, which otherwise might be effected. If these handicaps could be removed in the near future it would permit a considerable addition to the oil production of the country, probably more than enough to offset the normal decrease, at least for the period of the war.

Mexico is far from producing the quantity of oil that is available. This condition has been partly due to the chaotic political state of the country, the heavy taxation of the oil companies, and the uncertainty as to the future actions of the government. Even under present conditions the production of the existing wells is being greatly restricted because there are not enough tank steamers and tank cars to transport the products to market.

Basing estimates on the figures for 1915, but taking into account the present positions of the European battle fronts, the Allies appear to control about 96 per cent of the world's total production. The advantage is not, however, so great as it might appear, inasmuch as the 4 per cent controlled by the Central Powers is all within their own battle lines, while on all fronts except the Russian the Allies are obliged to transport their petroleum supplies across seas infested with German submarines, which are taking a heavy toll from the available supply of tank steamers. In this instance, the problem of transportation is even more serious than that of oil production.

CHAPTER III.

CALIFORNIA PETROLEUM FIELDS.

In this chapter we shall make a general survey of the California petroleum situation with reference to the following subjects:

I. Location and Description of Fields.
II. Withdrawals, Restorations and Reserves.
III. Legislation.
IV. Litigation.

I. *Location and Description of Fields.*

The proved petroleum fields of the state may, with minor exceptions, be classified as follows:

San Joaquin Valley fields.
Los Angeles-Orange County fields.
Coast fields.

The San Joaquin Valley fields are generally classified as the West Side fields, being, from north to south, the Coalinga field, the Lost Hills field, the Belridge field, the McKittrick field, the Midway field and the Sunset field; and the Kern River field.

The Los Angeles-Orange County fields, in order of productivity, are the Whittier-Fullerton field, the Salt Lake field, the Los Angeles City field and the Newhall field.

The Coast fields are located in Santa Barbara and Ventura counties. In Santa Barbara county are the Santa Maria, Lompoc, Summerland and Casmalia fields. The Ventura county fields consist of a number of small and entirely separate oil fields, principally located in the Santa Clara Valley.

We shall now refer to each proved petroleum field of importance in California, grouping the same for convenience by counties, and stating with reference to each field its location, its area, with acreage of proved territory, the year of initial and first active development, the productivity of the field, the characteristics of the field with reference to depth of wells and gravity of oil and the present number of producing wells. The characteristics of the various fields with reference to natural gas will be set forth in Chapter XI of this report. The counties, in order of productivity, are Kern, Los Angeles and Orange, Fresno, Santa Barbara and Ventura.

A map showing the California petroleum fields is attached to this report as Plate VI.

1. KERN COUNTY.

Midway Field.

The Midway field is the most productive petroleum field in California and one of the most productive in the United States.

This field is situated in the western portion of Kern County, along the northeasterly base of the Temblor Range, between the McKittrick field on the north and the Sunset field on the south. The boundary line between the Midway and the Sunset fields is the south line of township 32 south, ranges 23 and 24 east, M. D. M., which line is also the north line of township 12 north, ranges 23 and 24 west, S. B. M.

The Midway field has a total area of approximately 75 square miles and a proved oil territory of approximately 47,000 acres. The proved territory referred to in this chapter includes in each instance territory generally considered proved, between the main fields and the outlying wells.

Development in the Midway field commenced in 1900. Heavy production commenced in 1909. Production has increased from 4,235 barrels, in 1901, to 32,156,818 barrels in 1916. The greatest production was in 1914, in which year 37,479,228 barrels were produced. In 1915, due to litigation with the federal government, following the withdrawal orders, there was a sharp decline to 33,040,129 barrels.

The total production from 1900 to December 31, 1916, has been 197,580,255 barrels.

The depth of the wells in the Midway field varies from 500 to 4,000 feet. As a general rule, the upper sand is thicker and carries oil under 18 degrees Baume, while the lower sand is in most places less than 100 feet thick, produces oil lighter than 18 degrees Baume and frequently has gas pressure of several hundred pounds.

The gravity of the oil in the Midway field ranges from 13 degrees Baume to 30 degrees Baume. Approximately 40 per cent of the oil is of 18 degrees Baume or lower, the remaining 60 per cent being higher than 18 degrees Baume.

On December 31, 1916, there were approximately 1,710 producing wells in the combined area of the Midway field and the Sunset field, next hereinafter referred to. On March 1, 1917, there were 1,420 producing wells in the Midway field alone.

Sunset Field.

The Sunset field is an extension southeasterly of the Midway field along the northeasterly base of the Temblor Range, in the western part of Kern County.

The Sunset field has an area of approximately 15 square miles, with a proved acreage of approximately 9,500 acres.

The first well in the Sunset field was drilled in 1891 and systematic development was begun in 1894. The district became commercially important in 1900, in which year it contained 18 producing wells.

The production increased from 12,500 barrels in 1900 to 6,768,658 barrels in 1916. The maximum production was in 1914, in which year 12,546,615 barrels were produced, this production being practically double the production of 1913 and of 1915. Due to the enormous production of the Lakeview gusher, the production rose from approximately 2,000,000 barrels in 1909 to 9,218,904 barrels in 1910.

The total production of the Sunset field from 1900 to December 31, 1916, was 57,681,754 barrels.

The wells in the Sunset field vary in depth between 400 and 3,000 feet. A number of unsuccessful wells have been drilled to a depth in excess of 5,200 feet in the region east of the producing territory.

The gravity of the oil varies from 11 degrees to about 26 degrees Baume. Approximately 50 per cent of the oil is under 15 degrees Baume. The lighter oil, ranging from 13.5 to 26 degrees Baume, is found in the deeper wells in the northern end of the field.

As already indicated, the number of producing wells in the Midway and Sunset fields combined on December 31, 1916, was 1710. On March 1, 1917, the number of producing wells in the Sunset field alone was 342.

Kern River Field.

The Kern River field lies on the low rolling hills at the foot of the Sierra Nevada Range, on the eastern rim of the San Joaquin valley, approximately 4½ miles northeast of Bakersfield, Kern County.

The development of the Kern River field marked the beginning of California as a factor in world production of petroleum.

The area of the Kern River field is approximately 12 square miles, with a proved acreage of 7,900 acres.

The first well was drilled in June, 1899. By September, 1900, there were 134 completed wells in the field. The production has increased from 826,775 barrels in 1900 to a maximum of 17,226,240 barrels in 1904. Since 1904, the production has gradually decreased until in 1916 the production was 8,402,525 barrels.

The total production from 1900 to December 31, 1916, was 190,149,600 barrels. In point of total productivity to date, the Kern River field ranks second only to the Midway field.

The wells in the Kern River field vary in depth from 400 to 1,200 feet, with an average of approximately 900 feet. The producing sands range from a thickness of 200 feet to 500 feet.

The gravity of the oil varies from 10.4 to 17 degrees Baume, with an average of about 14 degrees. The oil from this district is used mainly for fuel and the manufacture of asphalt.

On December 31, 1916, there were 1,908 producing wells in this field. The number increased by March 1, 1917, to 1946 wells.

McKittrick Field.

The McKittrick field is located in the western portion of Kern County, about five miles northwest of the Midway field.

The McKittrick field has an area of approximately four square miles, with a proved acreage of 1,650 acres.

The McKittrick field was one of the first fields in which petroleum was produced in California. Development commenced in 1866, and at first consisted largely in mining for asphalt. The first successful well was drilled in 1892, but the first production of importance was 10,000 barrels in 1898. In 1900 there were 16 producing wells and seven drilling wells, with a total production for the year of 80,000 barrels.

The production increased steadily until it reached its maximum with 5,807,360 barrels in 1909. Since 1909 the production has gradually decreased. In 1916 the total production was 3,230,644 barrels.

The total production of the McKittrick field from 1898 to December 31, 1916, has been 48,862,217 barrels.

The wells in the McKittrick field vary in depth from 400 feet to 1,800 feet, with an average depth of 1,200 feet.

The gravity of the oil in the northern portion of the field ranges from 12.5 degrees to 21 degrees Baume, with an average of 15 degrees or 16 degrees Baume; in the central portion of the field, the gravity ranges between 12 degrees and 24 degrees Baume, with an average of 15 degrees to 17 degrees Baume; and in the southern portion of the field the gravity of the oil is fairly uniform at about 18 degrees Baume. In the valley and in the hills north of McKittrick Valley the gravity is approximately 12 to 14 degrees Baume.

On December 31, 1916, there were 293 producing wells in the McKittrick field. The number was the same on March 1, 1917.

Lost Hills Field.

The Lost Hills field is located in the western portion of Kern County, approximately 50 miles southeast of Coalinga. The developed territory

extends along a narrow strip of territory having a length of approximately six miles and a width varying between 2,000 and 4,000 feet.

The proved area of the Lost Hills field and the Belridge field combined is reported to be 4,200 acres.

The first well in the Lost Hills field was drilled in July, 1909. The first discovery of importance was the Martin and Dudley well, which was completed in the summer of 1910.

The production increased from 4,900 barrels in 1910 to a combined production of 5,274,553 barrels for the Lost Hills and Belridge fields in 1913. In 1916 the combined production of the Lost Hills and Belridge fields was 4,852,431 barrels.

The combined production of the Lost Hills and Belridge fields from 1910 to December 31, 1916, was 22,130,726 barrels.

The wells in the Lost Hills field range from 500 to 2,000 feet in depth.

The gravity ranges from 15 degrees to 38 degrees Baume. In the southern portion of the field the oil ranges from 30 degrees to 38 degrees Baume.

On December 31, 1916, there were 350 producing wells in the Lost Hills and Belridge fields combined. By March 1, 1917, this number had increased to 376 wells. During the month of March, 1917, 18 producing wells were added to the number, this number being second only to the 20 additional producing wells completed during March, 1917, in the Midway field.

Belridge Field.

The Belridge field is located in western Kern County, between the Lost Hills field to the north and the McKittrick field to the south. The proved territory is located in two separate areas.

The Belridge field has a width of between one-fourth to one-half mile and a length of about three miles, with a proved acreage for this field and the Lost Hills field together amounting to 4,200 acres.

Development in the Belridge field began in 1911. Practically the entire production in this field comes from the upper zone, in which the wells vary in depth from 600 to 900 feet. The lower zone, consisting of brown shale, is reached by wells having a depth of approximately 4,000 feet.

The production of the Belridge field has been combined with the production of the Lost Hills field in the description of the latter field hereinbefore given.

On June 1, 1916, there were 86 producing wells in the Belridge field.

2. LOS ANGELES AND ORANGE COUNTIES.

By reason of very largely increased production in the Whittier-Fullerton field, Los Angeles and Orange counties now rank second among the counties of California in the production of petroleum. In order of productivity, the petroleum fields of Los Angeles and Orange counties are as follows:

1. Whittier-Fullerton field.
2. Salt Lake field.
3. Los Angeles City field.
4. Newhall field.

Whittier-Fullerton Field.

The Whittier-Fullerton field is located in the eastern portion of Los Angeles County and the northwestern portion of Orange County.

This field is at times further segregated into a number of fields which, in order of present productivity, are as follows: Coyote Hills, La Habra, Brea Canyon (or Fullerton), Olinda, Whittier, Baldwin (or La Mereed) and Puente.

The field covers an area of approximately 15 square miles, with a proved acreage of approximately 5,000 acres.

The first production of consequence in the Whittier-Fullerton field was in 1897, in which year 12,000 barrels were produced. The production has steadily increased until in 1916 it amounted to 14,679,672 barrels.

The total production from 1897 to December 31, 1916, was 97,428,665 barrels. In March, 1917, the daily production of the Whittier-Fullerton field of 47,455 barrels was surpassed only by the daily production of 81,641 barrels of the Midway field.

The daily production as of May 1, 1917, of the various fields which constitute in the aggregate the Whittier-Fullerton field was as follows:

Coyote Hills field	20,483 barrels
La Habra field	10,766 barrels
Brea Canyon (or Fullerton) field	6,314 barrels
Olinda field	5,956 barrels
Whittier field	2,893 barrels
Baldwin (or La Merced) field	545 barrels
Puente field	66 barrels

The characteristics of the various smaller fields which in the aggregate constitute the Whittier-Fullerton field differ with reference to depth of wells, gravity of oil and other characteristics.

The wells range in depth from the shallow wells of the Puente field, having a depth of from 700 to 2,300 feet, to the deep wells of the Coyote Hills field, having a depth of from 3,500 to 5,000 feet. The gravity of the oil ranges from 14 degrees to 15 degrees Baume in some

fields to in excess of 35 degrees Baume in the Coyote Hills and Brea Canyon fields.

On December 31, 1916, there were 637 producing wells in the Whittier-Fullerton field.

On May 1, 1917, there were 665 producing wells, as follows:

Coyote Hills field	57
La Habra field	116
Brea Canyon field	91
Olinda field	226
Whittier field	116
Baldwin field	1
Puente field	58
	665

It may be noted that the 57 wells producing in Coyote Hills field averaged in May, 1917, a daily production of 360 barrels each.

Salt Lake Field.

The Salt Lake field includes the territory lying between the western city limits of the city of Los Angeles and the Pacific Ocean. This field is located about two miles to the south of the base of the Santa Monica Mountains and slopes gently to the south and west.

The Salt Lake field has an area of approximately two square miles, with a proved acreage of approximately 1,200 acres.

The first well in the Salt Lake field was drilled in 1901. No definite record of production prior to 1906 is obtainable for the reason that up to 1906 the Salt Lake field was generally considered as part of the Los Angeles City field. In 1906 the production of the Salt Lake field was 2,435,530 barrels. The maximum production was 4,535,800 barrels in 1908. Subsequent to 1908, production has slowly decreased, until in 1916 the Salt Lake field combined with the Los Angeles City field produced only 1,721,453 barrels.

The combined production of the Salt Lake field and the Los Angeles City field from 1894 to December 31, 1916, was 51,400,532 barrels.

The wells in the Salt Lake field range from a depth of 800 to 3,000 feet, the average depth of the producing wells being approximately 1,725 feet.

The gravity of the oil in this field ranges from 10 degrees to 25 degrees Baume.

The total number of producing wells in the combined Salt Lake and Los Angeles City fields on December 31, 1916, was 674 and on March 1, 1917, 673. On March 1, 1917, the total number of producing wells in the Salt Lake field was 273.

Los Angeles City Field.

The Los Angeles City field consists of a narrow belt about five and one-half miles long running through the northern portion of the city of Los Angeles.

The proved area in this field comprises some 1,400 acres.

The presence of oil and gas in the city of Los Angeles was known at an early date. In 1865 a well sunk near Temple street produced some gas. The first producing oil well in the city of Los Angeles was drilled in 1892 by Doheny and Cannon, at Second Street Park. By the end of 1895 there were more than 300 producing wells in the city of Los Angeles. The total production in 1894, the first year of active development, was 257,109 barrels. In 1895 the production increased to 751,945 barrels, being at the rate of six or seven barrels per well per day. By 1916 the number of producing wells decreased to approximately 400, and the production for 1916 combined with that of the Salt Lake field was 1,721,453 barrels.

The wells in the Los Angeles City field vary in depth from 500 to 1,200 feet.

The gravity of the oil ranges from 12 degrees to 19 degrees Baume. This oil is of little value for refining, but is used as fuel oil in the local market.

On March 1, 1917, there were 400 producing wells in the city of Los Angeles. No additional wells are being drilled.

Newhall Field.

The Newhall field is located in Los Angeles County, approximately 40 miles northwest of the city of Los Angeles. This field is frequently classed with the Ventura County fields for the reason that it is located in an extension of the Santa Clara Valley, which is principally located in Ventura County.

Included in the Newhall field are the Pico Canyon, Wiley Canyon and Elsmere Canyon fields.

The proved territory in the Newhall field has been roughly estimated at about 540 acres, but close figures are impossible because of the character of the country and the fact that the groups of wells are small and widely scattered and have very little apparent connection with one another.

Development in the Newhall field began in 1875, with the drilling of three shallow wells in Pico Canyon. In 1880 the output was 40,500 barrels. In 1895 approximately 35 wells yielded an annual production of 150,000 barrels. In 1910, 75 producing wells yielded an annual output of 160,428 barrels, the largest output in the history of this field.

In March, 1917, the total production was 11,574 barrels, being an average production of 4.6 barrels daily per well.

The total combined production of the Newhall and the Ventura County fields from the beginning to December 31, 1916, was 18,738,338 barrels. Separate figures for the Newhall field alone are not available.

The depth of the wells in the Newhall field varies from 700 to 1,600 feet, with an average depth of less than 1,000 feet per well.

The gravity of the oil in this field varies greatly from 11 degrees to 38.7 degrees Baume. The average gravity of the oil in Pico Canyon is approximately 38 degrees Baume, in Wiley Canyon 30 degrees Baume, and in Elsmere Canyon 14 degrees Baúme.

On December 31, 1916, there were 80 producing wells in the Newhall field. On March 1, 1917, there were the same number of producing wells, with one additional well being drilled.

3. FRESNO COUNTY.

Coalinga Field.

The Coalinga field is located in the southwestern portion of Fresno County and the western portion of Kings County. The field has a total area of 750 square miles, but the proved oil land has an area of only 17,500 acres and is located entirely in the foothill region around Pleasant Valley in Fresno County.

The Coalinga field is subdivided into three smaller proved fields known respectively as the Oil City field, lying on the crest of the Coalinga anticline at the north end of the field; the Eastside field, lying on the crest and on the east flank of the Coalinga anticline and forming the northeastern portion of the Coalinga field, and the Westside field, lying on the western flank of the Coalinga syncline in the western part of the field. Petroleum, but not in commercial quantities, has also been found in isolated spots in other portions of the Coalinga field, known as Kettleman Hills, Kreyenhagen Hills and Jacalitos Canyon.

The first successful well in the Coalinga field was completed in 1890 in the Oil City field. Development in the Eastside field began with the drilling of a number of wells in 1900. In the Westside field, successful development work was begun in 1901 and by the fall of 1906 the present limits of the field had been ascertained.

The production in the Coalinga field increased rapidly from 14,119 barrels in 1896, until in 1912 it reached 19,546,122 barrels. The production in 1916 was 14,381,493 barrels, this being an increase of approximately 800,000 barrels over 1915. The increasing production in the Coalinga field is principally from the Eastside field.

The total production of the Coalinga field from 1896 to December 31, 1916, was 180,934,188 barrels.

In point of total production to date, the Coalinga field ranks third among California petroleum fields, being exceeded only by the Midway and the Kern River fields. In point of present production, the Coalinga field likewise ranks third, being exceeded only by the Midway and the Whittier-Fullerton fields.

The wells in the Coalinga field range in depth from 300 to 4,700 feet and the gravity of the oil from 12.4 degrees to 35.5 degrees Baume. The well depths and the range of gravity in the three proved fields are as follows:

Field	Depth of wells in feet	Gravity in degrees Baume
Oil City	300 to 1,700	34.5 to 35.5
Eastside	700 to 4,700	17.6 to 30.7
Westside	500 to 3,300	12.4 to 20

On December 31, 1916, there were 949 producing wells in the Coalinga field. On March 1, 1917, the number had decreased to 942, but 10 additional wells were completed during the month.

4. SANTA BARBARA COUNTY.

The petroleum fields of Santa Barbara County are generally referred to as the Santa Maria field and the Summerland field.

Santa Maria Field.

The Santa Maria field is located in the northern portion of Santa Barbara County, in the region of rolling hills between the Santa Ynez and San Rafael mountains. The territory nominally designated as the Santa Maria field includes three principal fields, known respectively as the Santa Maria or Orcutt field, the Lompoc field and the Cat Canyon field. Within the last year very active development work has progressed in the westerly part of the Orcutt field, known as the Casmalia field. The Orcutt field is the most important of the subdivisions of the Santa Maria field, and has a proved acreage of approximately 4,000 acres. The Cat Canyon field is an extension to the east of the Santa Maria field and has a proved acreage of approximately 1,600 acres. The Lompoc field is located about five miles north of the town of Lompoc and has a proved acreage of approximately 1,600 acres. The Casmalia field is an extension westerly of the Orcutt field and is at present in process of being developed.

The first successful well in the Santa Maria field was completed in the Orcutt field in August, 1901. The production in this field in 1902 was 86,888 barrels. The first well in the Cat Canyon field was completed in 1908. The production of these two fields was 8,159,136 barrels in 1907 and 8,430,230 barrels in 1908. Commercial production in the Lompoc field commenced in 1906, during which year the output was 46,400 barrels.

The production of the three fields comprising the general Santa Maria field increased from 86,888 barrels in 1902 to a maximum of 8,699,350 barrels in 1908. Subsequent to 1908, the production has gradually decreased, being 4,422,410 barrels in 1916.

The total production of these three fields from 1902 to December 31, 1916, was 75,115,391 barrels, of which amount approximately 5,700,000 barrels were produced in the Lompoc field.

The wells in the Orcutt field have a depth of 2,000 to 4,000 feet, the average depth being approximately 3,000 feet; in the Cat Canyon field, 2,400 to 3,200 feet, with an average depth of 3,000 feet; and in the Lompoc field, from 2,500 to 4,400 feet, with an average depth of 2,700 feet.

The oil in the Orcutt field ranges in gravity from 20 to 35 degrees Baume and is used principally for refining. The oil in the Cat Canyon field is heavy and viscous, ranging from 11 to 19 degrees Baume, and is mainly used for fuel, road dressing and asphalt. The oil in the Lompoc field ranges in gravity from 16 to 37 degrees Baume and is valuable for refining. The oil in the Casmalia field is of 11 degrees Baume and heavier and accordingly is difficult to handle except when hot.

The number of producing wells in the three fields combined on December 31, 1916, was 249, of which number 222 were in the Orcutt and Cat Canyon fields and 27 in the Lompoc field. On March 1, 1917, the number of producing wells in the Orcutt and Cat Canyon fields had increased to 227 (including the Casmalia field), while the number in the Lompoc field remained 27.

Of the 44 wells drilling and the 17 rigs completed in the Santa Maria field in March, 1917, almost all are located in the Casmalia field. The activity in this relatively small field was exceeded during this month only by the drilling in the extensive Midway and Whittier-Fullerton fields.

Summerland Field.

The Summerland field is located on the Pacific Ocean about six miles southeast from Santa Barbara and is unique in that its petroleum is secured principally from wells drilled into the sands lying beneath the Pacific Ocean.

The field is very small, the proved acreage being only 230, or about one-third of one square mile.

The first well was completed in 1891 and commercial production started in 1894 with 1,500 barrels. The maximum production in this field was 208,370 barrels in 1899, since which year the production has rapidly diminished. In 1916, 56,775 barrels were produced in this field. The present average daily production of 1.4 barrels per well in this field is by far the smallest production in any proved field in the state.

The total production of the Summerland field from 1894 to December 31, 1916, was 2,123,764 barrels.

The wells in this field range in depth from 80 to 600 feet.

The gravity of the oil varies from 9 to 18 degrees Baume, the average being about 14 degrees Baume. The oil is very viscous and is principally used for road dressing and fuel oil.

The number of producing wells in this field on December 31, 1916, was 112. The same number were still operating on March 1, 1917.

5. VENTURA COUNTY.

The Ventura field consists of small, separate fields on either side of the Santa Clara Valley, extending from the Newhall field in Los Angeles County, hereinbefore referred to, to the Ojai Valley in Ventura County, about 50 miles farther west, with a proved acreage of approximately 4,500 acres.

Ventura County is the oldest oil producing district in California. As early as 1866, 3,078 barrels of oil were produced and shipped during a period of ten months. The Santa Clara Valley produced practically all the petroleum in California up to 1880, when the Puente Hills field was discovered. By 1894 the annual production increased to 290,913 barrels, produced by 45 wells. The production gradually increased to 542,902 barrels in 1903, after which year there was a marked decrease in production. Beginning with 1912 a steady increase in production again took place. The production in 1912 was 662,300 barrels; in 1913, 899,007 barrels, and in 1916 approximately 1,000,000 barrels.

The total combined production of Ventura County and the Newhall field (in Los Angeles County) from the beginning of production, antedating 1876, to December 31, 1916, was 18,738,338 barrels.

The wells in Ventura County vary in depth from 200 to 3,700 feet, a large number having a depth of less than 1,000 feet.

The gravity ranges from 12 or 13 degrees Baume to 54 degrees Baume. The bulk of the petroleum produced in Ventura County is of refining grade.

On December 31, 1916, there were 366 producing wells in the county. On March 1, 1917, the same number of wells were producing, but 31 additional wells were being drilled, this being the largest number of wells being drilled in any field except Midway, Whittier-Fullerton, Coalinga and Santa Maria (principally Casmalia).

Table 3 shows in summary form the salient facts with reference to the California petroleum fields as hereinbefore set forth.

TABLE

Location, Development and Production of the

Field	Location of field	Area		Date of development	
		Square miles	Proved acreage	Initial	First active
Midway	Western part of Kern County along the northeastern base of Temblor Range, between McKittrick and Sunset Fields	73	47,000	1900	1909
Sunset	Continuation, to the southeast, of the Midway Field.	15	9,500	1891	1900
Kern River	In Kern County about 4½ miles northeast of Bakersfield.	12	7,900	1899	1900
McKittrick	In Kern County about 5 miles northwest of Midway Field.	4	1,650	1866	1898
Lost Hills	In Kern County, between Coalinga and McKittrick Fields.	3½	4,200	1909	1910
Belridge	In Kern County about 1½ miles northwest of McKittrick Field.	1¼		1911	1911
Coalinga	In western Fresno County along the northeastern base of the Mount Diablo Range.	35	17,500	1890	1896
Whittier-Fullerton.	In eastern part of Los Angeles and northwestern part of Orange counties.	15	5,000	1882	1897
Los Angeles	In the low hills running through the northern part of the city of Los Angeles.	2	1,400	1892	1894
Salt Lake	About 4½ miles west of the business district of the city of Los Angeles.	2	1,200	1901	1904
Newhall	In Los Angeles County, some 40 miles northwest of center of the city of Los Angeles.	--------	*540	1875	1880
Ventura	Small and entirely separate fields in the southeastern half of Ventura County.	--------	*4,500	1866	1870
Santa Maria and	In northern Santa Barbara County between Santa Ynez and San Rafael Mountains.	9	4,000	1901	1902
Cat Canyon			1,600	1908	1908
Lompoc	About 5 miles north of Lompoc.	2½	1,600	1904	1906
Summerland	On the Santa Barbara Channel about 6 miles southeast of Santa Barbara.	⅓	230	1891	1894

*Estimated.

3.

Principal Petroleum Fields of California.

Production in barrels				Depth of wells, feet	Gravity of oil	Producing wells, oil and gas, Dec. 31, 1916
First year of active development	Year of maximum development	Year of 1916	Total to Jan. 1, 1917			
2,234,455	37,479,228 (1914)	32,156,818	197,580,255	500 to 4,000	13 to 30° B.	*1,255
12,500	12,546,615 (1914)	6,768,658	57,681,754	400 to 3,000	11 to 26° B.	*455
826,775	17,226,240 (1904)	8,402,525	190,149,600	400 to 1,200; average 900	10.4 to 17° B.; average 14°	1,908
10,000	5,807,360 (1909)	3,230,644	48,862,217	400 to 1,800; average 1,200	12.5 to 21° B.; average 15°	293
4,900	5,274,553 (1913)	4,852,431	22,130,726	500 to 2,000 600 to 4,700	15 to 38° B.; average 28°	350
14,119	19,546,132 (1912)	14,381,493	180,934,188	300 to 4,700	12.4 to 35.5° B.	949
12,000	14,679,672 (1916)	14,679,672	97,428,665	700 to 5,000	14 to 35° B.	637
257,109	751,945 (1895)	1,721,453	51,400,532	500 to 1,200	12 to 19° B.	400
*500,000	4,535,800 (1908)			800 to 3,000; average 1,725	10 to 25° B.	273
40,500	160,428 (1910)	1,122,033	18,738,338	700 to 6,000; average 1,000	11 to 38.7° B.	80
3,078	*1,000,000 (1916)			200 to 3,700	12 to 40° B.; *5/6 above 18°	366
} 86,888	8,430,230 (1908)	*3,900,000	*69,400,000	2,000 to 4,000—average 3,000. 2,400 to 3,200—average 3,000.	20 to 35° B. 11 to 19° B.	222
46,400	1,013,880 (1912)	*500,000	*5,700,000	2,500 to 4,400—average 2,700.	16 to 37° B.	27
		4,422,410 (Total)	75,115,391 (Total)			
1,500	208,370 (1899)	56,775	2,123,764	80 to 600	9 to 18° B.; average 14°	112

Table 4 shows the field development and production of California petroleum fields as reported by Standard Oil Company of California as of December 31, 1916. The proved acreage shown includes the territory between the main fields and the outlying wells, generally considered "proved."

II. *Withdrawals, Restorations and Reservations.*

1. Withdrawals and Restorations.

An understanding of the petroleum situation in California requires a reference to the withdrawals by the federal government of public lands in California from entry and to the restoration of portions thereof from time to time.

While a number of withdrawals and restorations were made prior to September 27, 1909, the principal withdrawals of California petroleum lands were made on and subsequent to September 27, 1909.

On February 24, 1908, Mr. George Otis Smith, director of the United State Geological Survey, wrote to the Secretary of the Interior a letter, which reads in part as follows:

> "It will be easy, if desired, to multiply the authoritative statements already in print concerning the superiority of liquid fuel for the Navy. For that reason I have to recommend that the filing of claims to oil lands in the state of California be suspended in order that the government may continue ownership of valuable supplies of liquid fuel in this region where all fuel is expensive.
>
> "It is evident from the many reports on the superiority of liquid fuel that the question of its adoption is simply a question as to the price at which suitable petroleum products can be purchased.
>
> "The present rate at which the oil lands in California are being patented by private parties will make it impossible for the people of the United States to continue ownership of oil lands there more than a few months. After that, the government will be obliged to repurchase the very oil that it has practically given away."

Mr. Smith also refers in his letter to the inadequacy of the coal supply on the Pacific coast.

On November 11, 1908, Mr. David T. Day, expert in charge of petroleum, and Mr. Ralph Arnold, expert in charge of California petroleum, wrote to the Director of the United States Geological Survey "that the withdrawal of public lands known to contain petroleum is an immediate necessity for the adequate supply of this material during the remainder of the century or even for the next fifty years." The letter continues as follows:

> "This condition is due not to the popularity of petroleum, but to the character of the production, which consists in realizing on the petroleum contained in one lease before it can be pumped through the wells of an adjoining lease. This situation renders imperative

TABLE 4.

California Petroleum—Field Development and Production, December 31, 1916.

Field	Proved acreage	Daily production, barrels	Number of producing wells	Daily production per well	Daily production per acre	Number of acres per well	Total production to Dec. 31, 1916	Production per acre to Dec. 31, 1916
Kern River	7,900	22,495	1,908	11.8	2.85	4.1	190,149,600	24,100
McKittrick	1,650	8,812	293	30.1	5.34	5.6	48,862,217	29,600
Midway-Sunset	56,538	102,217	1,710	59.8	1.81	33.1	255,262,009	4,500
Lost Hills-Belridge	4,200	14,719	350	42.1	3.50	12.0	22,130,726	5,300
Coalinga	17,500	43,215	949	45.5	2.47	18.4	180,934,188	10,300
Lompoc and Santa Maria	7,265	12,890	249	51.8	1.77	29.2	75,115,391	10,300
Ventura County and Newhall	5,000	2,882	446	6.5	.58	11.2	18,738,338	3,700
Los Angeles and Salt Lake	2,700	4,396	674	6.5	1.63	4.0	51,400,532	19,000
Whittier-Fullerton	5,000	44,127	637	69.3	8.82	7.9	97,428,665	19,500
Summerland	230	155	112	1.4	.67	2.1	2,123,764	9,200
Miscellaneous	200	75	5	15.0	.38	40.0	937,352	4,700
Totals	108,183	255,983	7,333	34.9	2.37	14.8	943,082,782	8,700

favorable action on the recommendation made last year in the letter of which we enclose a copy.''

[Letter of February 24, 1908, from the Director to the Secretary of the Interior.]

On September 17, 1909, Mr. George Otis Smith, Director of the United States Geological Survey, wrote to the Secretary of the Interior as follows:

September 17, 1909.

The Honorable, The Secretary of the Interior.

SIR: I have the honor to transmit herewith a copy of a letter addressed to your predecessor in February, 1908. The arguments presented in support of the recommendation made at that time are still valid, and they have been amplified in the Survey's Conservation Report on the Petroleum Resources of the United States, a copy of which I submit herewith. In this report it is shown that the present production of petroleum exceeds the legitimate demands of the trade and that inasmuch as the disposal of the public petroleum lands at nominal prices simply encourages overproduction the logical method of checking this unnecessary waste would be to secure the enactment of legislation that would provide for the sane development of this important resource. In view of the well-known facts of the mode of occurrence of oil and the all-too-common practice of drilling wells close to boundary lines of private holdings that are being developed for oil, conservation of the petroleum supply demands a law that will provide for disposal of the oil remaining in the public domain in terms of barrels of oil rather than of acres of land.

I have the honor to also call your attention to the estimate in the petroleum report that at least one-half pint of lubricating oil is used for every ton of coal converted into power, and that this quantity of lubricating oil represents over a half-gallon of crude petroleum. Taking this into account as well as the increasing use of fuel oil by the American Navy, there would appear to be an immediate necessity for assuring the conservation of a proper supply of petroleum for the government's own use. I would therefore renew my recommendation that pending the enactment of adequate legislation on this subject, the filing of claims to oil land in the state of California be suspended.

In this connection it is important to note that acting on my report of June 4, 1909, classifying certain oil lands in California, the Commissioner of the General Land Office issued instructions to registers and receivers to withhold those oil lands from agricultural entry pending consideration of the question of legislation. The area of oil land affected by this action is about 427,000 acres, to at least 40 per cent of which the government retains title. In several townships, notably T. 32 S., R. 22 E.; T. 32 S., R. 23 E.; T. 32 S., R. 21 E.; T. 30 S., R. 21 E.; T. 31 S., R. 23 E.; T. 31 S., R. 22 E.; T. 31 S., R. 24 E. of the Mount Diablo Meridian; and in T. 11 N., R. 24 W., and T. 12 N., R. 25 W., of the San Bernardino Meridian, there are compact areas of unappropriated oil land, each including from 6 to 16 contiguous sections.

Very respectfully,

GEO. OTIS SMITH,

Director.

On September 17, 1909, Secretary Ballinger wrote to President Taft recommending that in aid of such legislative action as would assure the conservation of an adequate supply of petroleum for the government's own needs, the oil lands referred to in the letter should be withdrawn from all forms of filing, entry and disposal, including mineral entry. This letter reads as follows:

September 17, 1909.

The President, White House.

SIR: I have the honor to bring to your attention the subject of the conservation of the petroleum resources of the public domain, with special reference to the present and future requirements of the American Navy.

The six largest battleships in commission or under construction are equipped for the use of either oil or coal and the fourteen latest destroyers use oil exclusively.

The Geological Survey reports that the present rate of production of petroleum can not be maintained beyond a very few years, after which a marked decrease will result in an insufficient supply and increased prices. At present the production exceeds the legitimate demands of the trade and inasmuch as the disposal of the public petroleum lands at nominal prices simply encourages overproduction, the logical method of checking this unnecessary waste would be to secure the enactment of legislation that would provide for the sane development of this important resource. In view of the well-known facts of the mode of occurrence of oil and the all-too-common practice of drilling wells close to the boundary lines of private holdings that are being developed for oil, conservation of the petroleum supply demands a law that will provide for the disposal of the oil remaining in the public domain in terms of barrels of oil rather than of acres of land.

The Navy has a further interest in the conservation of the petroleum supply by reason of the absolutely necessary use of petroleum products for lubrication. A very conservative estimate is that at least one-half pint of lubricating oil is used for every ton of coal converted into power and that this quantity of lubricating oil represents over a half-gallon of crude petroleum.

The recommendation was made by the Director of the Geological Survey in February, 1908, to my predecessor that the filing of claims to oil land in the state of California be suspended in order that the government may continue the ownership of a sufficient supply of petroleum on the Pacific Coast where other fuel is expensive. No action to this end has been taken.

Acting upon the Survey's report of June 4, 1909, classifying oil lands in California, the Commissioner of the General Land Office on June 22, 1909, issued instructions to the registers and receivers to withhold these oil lands from agricultural entry, pending consideration of the question of legislation. The area classified as oil land is 430,000 acres, to at least 40 per cent of which the government still retains title. In several townships in this tract there are compact areas of unappropriated oil land, each including from 6 to 16 contiguous square miles.

As a result of previous work by the Geological Survey, similar action was taken in June, 1908, on 150,240 acres in California, classified as oil land, the title to a considerable portion of which is believed to remain in the government. Furthermore there is at present withdrawn in California pending examination and classification by the Geological Survey, which work is now in progress, approximately 1,650,000 acres, of which 1,250,000 acres are withdrawn from all entry.

The time appears opportune for legislative action that will assure the conservation of an adequate supply of petroleum for the government's own needs. This legislation should give authority to fix the terms of disposition of public oil lands so as to provide for the future demands of the Navy and should also authorize the permanent reservation of such areas as the Executive, after full investigation, may find necessary for this federal purpose. It is believed that such legislation would not interfere with the profitable development and utilization of the California oil pools.

In aid of such legislation and indeed as essential to the accomplishment of its purpose, all the lands hereinbefore mentioned should be temporarily withdrawn from all forms of filing, entry and disposal, including mineral entry.

I have the honor to be,

Very respectfully,

R. A. Ballinger,

Secretary.

On September 27, 1909, by Temporary Petroleum Withdrawal No. 5, 3,041,000 acres of lands which were supposed to contain petroleum were withdrawn from all forms of location, settlement, selection, filing, entry or disposal under the mineral or nonmineral public land laws. This acreage includes a large amount of land which had already been patented, or to which other valid claims had attached. The order of withdrawal reads in part as follows:

> "In aid of proposed legislation affecting the use and disposition of the petroleum deposits on the public domain, all public lands in the accompanying lists are hereby temporarily withdrawn from all forms of location, settlement, selection, filing, entry, or disposal under the mineral or nonmineral public land laws. All locations or claims existing and valid on this date may proceed to entry in the usual manner after field investigation and examination."

Of the 3,041,000 acres of land included in this withdrawal order, 2,871,000 acres were located in California and 170,000 acres in Wyoming.

On June 25, 1910, congress specifically authorized the President at any time, in his discretion, to temporarily withdraw from settlement, location, sale or entry any of the public lands of the United States, including the District of Alaska, and to reserve the same for water power sites, irrigation, classification of lands, or other public purposes to be specified in the orders of withdrawal, and provided that such

withdrawals or reservation should remain in force until revoked by the President or by an act of congress (36 Stat. 847).

On July 2, 1910, President Taft authorized orders of withdrawal affecting California and other states. The order affecting California involved approximately 2,482,750 acres. This order ratified and confirmed, with reference to the lands therein described, a number of former temporary withdrawal orders, as follows:

September	27, 1909,	Temporary Petroleum Withdrawal No. 5
October	30, 1909,	Temporary Petroleum Withdrawal No. 8
November	16, 1909,	Temporary Petroleum Withdrawal No. 9
January	18, 1910,	Temporary Petroleum Withdrawal No. 11
February	2, 1910,	Temporary Petroleum Withdrawal No. 12

Subsequent to July 2, 1910, a number of withdrawal orders and restoration orders affecting California were made. These orders are all set forth in Bulletin No. 623, United States Geological Survey (1916).

The status of California petroleum lands included in withdrawal orders is reported in said Bulletin No. 623 to have been, in April, 1915, as follows:

	Acres	
Patented—		
Under railroad grants	308,075	
Under other nonmineral laws	708,441	
Under mineral laws	38,668	
Total patented		1,055,184
Unpatented—		
Covered by railroad selection	160	
Covered by other nonmineral entry or selection	60,911	
Covered by mineral application for patent	40,790	
Vacant or covered by mineral location	350,833	
Total unpatented		452,694
Total withdrawn		1,507,878

On June 30, 1916, Commissioner Tallman of the General Land Office reported to the Special Joint Conference of the Committees on Public Lands of the United States Congress that the outstanding withdrawals of California petroleum lands were as follows:

	Acres
Patented	899,103.78
Mineral entries	35,539.81
Agricultural entries	84,862.18
Vacant or embraced in agricultural entries under the Surface Act	341,608.88
Total	1,361,114.65

It will be observed from the foregoing figures that the lands included in the withdrawn area include a large acreage of lands already patented and of other lands on which entry has been made.

The withdrawn area includes all or a part of the oil fields of Coalinga, Lost Hills, Belridge, McKittrick, Midway, Sunset and Kern River, all located in the San Joaquin Valley, and a small acreage at Whittier and Olinda, in the Whittier-Fullerton field in Los Angeles and Orange counties. The withdrawn area also includes lands not located within

any field now regarded as proved territory, including particularly a large area of land in the eastern portion of Monterey and San Luis Obispo counties. A map showing accurately the withdrawn area as of November 1, 1915, accompanies Bulletin No. 623, United States Geological Survey.

2. Naval Reserves.

A part of the withdrawn area in California has been set aside as Naval Reserves Nos. 1 and 2 for the use of the Navy, in so far as the lands in these reserves are not subject to valid claim by private parties.

Naval Reserve No. 1.

Naval Reserve No. 1 includes 38,072.71 acres in the Elk Hills, Midway field, Kern County, California.

This reserve was created on September 2, 1912, by order of President Taft, reading as follows:

ORDER OF WITHDRAWAL.

Naval Petroleum Reserve No. 1.

It is hereby ordered that all lands included in the following list and heretofore forming a part of Petroleum Reserve No. 2, California No. 1, withdrawn on July 2, 1910, from settlement, location, sale, or entry and reserved for classification and in aid of legislation under the authority of the act of congress entitled "An act to authorize the President of the United States to make withdrawals of public lands in certain cases (36 Stat., 847)," shall hereafter, subject to valid existing rights, constitute Naval Petroleum Reserve No. 1 and shall be held for the exclusive use or benefit of the United States Navy until this order is revoked by the President or by act of congress. To this end and for this public purpose, the order of July 2, 1910, is modified and the withdrawal of that date is continued and extended in so far as it affects these lands.

Mt. Diablo Meridian.

T. 30 S., R. 22 E., Sec. 24, all.

T. 30 S., R. 23 E., Sec. 10, all; Secs. 12 to 30, inclusive; Secs. 32 to 36, inclusive.

T. 31 S., R. 23 E., Secs. 1 to 4, inclusive; Secs. 10 to 14, inclusive.

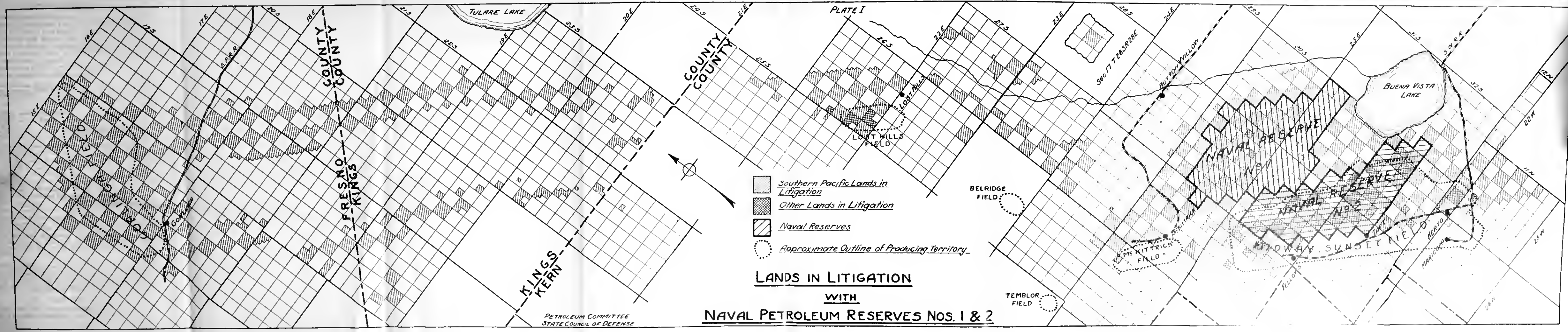
T. 30 S., R. 24 E., Secs. 17 to 20, inclusive; Secs. 28 to 34, inclusive.

T. 31 S., R. 24 E., Secs. 1 to 12, inclusive; Sec. 18, all.

WM. H. TAFT,
President.

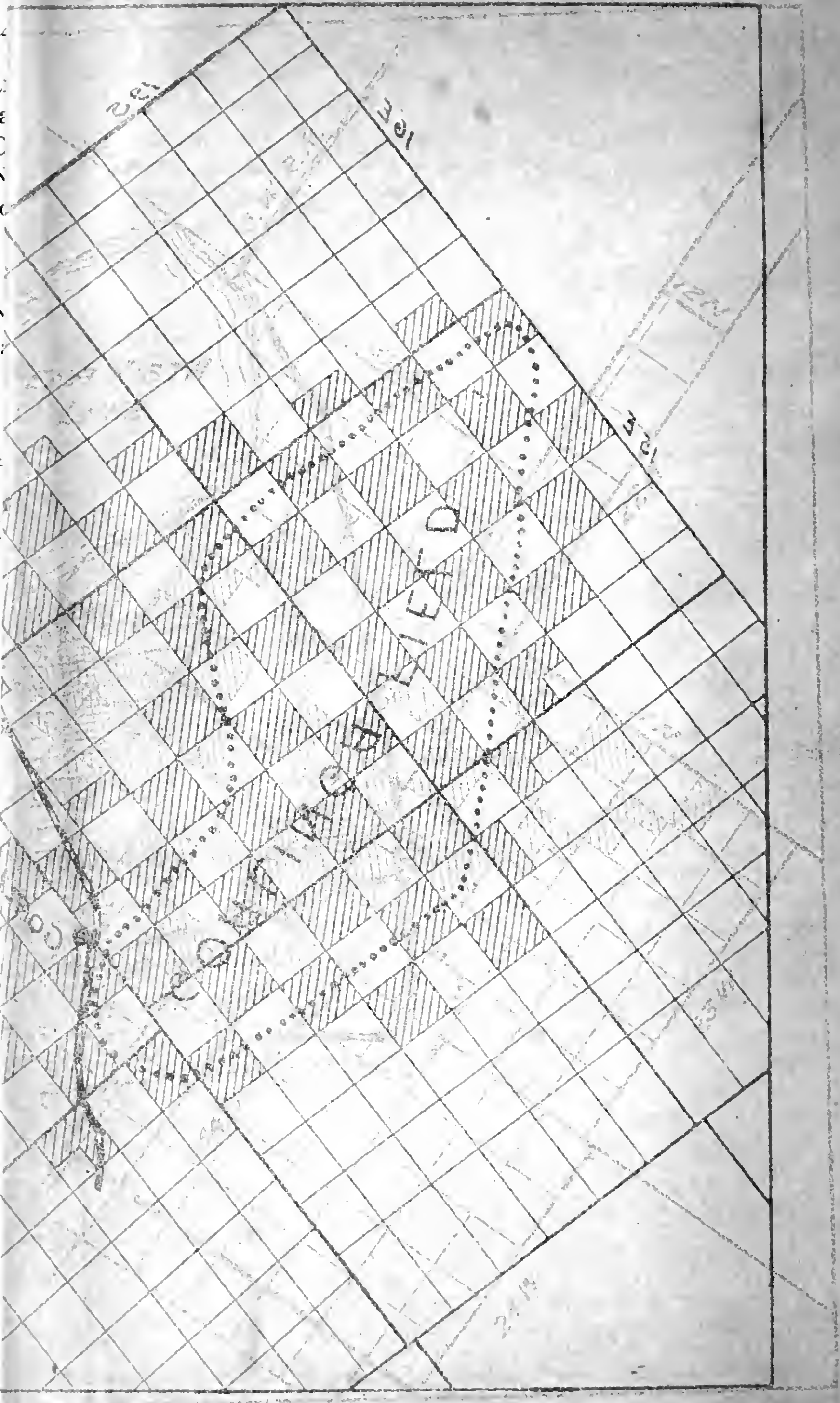
The status of the land in Naval Reserve No. 1, on December 20, 1916, was as follows:

	Acres
Patented to Southern Pacific Railroad Company (16¾ sections)	10,770.70
Patented to other parties (2 school sections)	1,332.39
Pending mineral applications (10)	4,532.95
Vacant and unentered on General Land Office records	21,436.67
Total area (59 sections)	38,072.71



LANDS IN LITIGATION WITH NAVAL PETROLEUM RESERVES NOS. 1 & 2

Petroleum Committee
State Council of Defense


COAL FIELD

The federal government has brought suit to cancel the patents heretofore issued to the Southern Pacific Railroad Company covering the entire area of 10,770.70 acres claimed by the railroad company in this reserve. Of this area, 6,109.17 acres are included in Case No. 221, known as the Elk Hills suit, which suit was won by the government in the District Court and is now pending on appeal before the United States Circuit Court of Appeals.

The status of the 4,532.95 acres affected by pending mineral applications was, on December 20, 1916, as follows:

	Acres
Adverse proceedings directed	2,772.31
Private contests or adverse suits	1,600.64
Pending investigation	160.00
Total	4,532.95

Two of the so-called withdrawal suits hereinafter referred to affect land in this reserve as follows:

No. of suit	Land affected
Case A-31	S. E. ¼ Sec. 26, T. 30 S., R. 23 E., M. D. M.
Case A-68	S. W. ¼ Sec. 24, T. 30 S., R. 23 E., M. D. M.

The claimant in these two suits is Associated Oil Company.

Approximately 27 wells have heretofore been drilled in Naval Reserve No. 1. Of these wells, three entered the oil sand, but they have been shut down and are not producing. At the present time there is no producing well in Naval Reserve No. 1.

In letter dated April 24, 1916, to Senator Henry L. Myers, Hon. Franklin K. Lane, Secretary of the Interior, refers to the possible petroleum content of Naval Reserve No. 1 as follows:

> "The Elk Hills in the Westside fields of California are structurally favorable for the accumulation of oil and gas, and they were considered as prospective oil lands by the Survey when it first examined them. Since that time a few wells have been drilled here and have proved that oil is present in considerable quantity. The amount of oil available has been estimated roughly by comparing the area with other productive areas that have similar geological features, and is placed at approximately 100,000,000 barrels."

Mr. W. A. Williams, testifying before the Special Joint Conference of the Committees on Public Lands, United States Congress, on December 19, 1916, stated that in his judgment the oil content of Naval Reserve No. 1 is approximately 128,800,000 barrels.

Naval Reserve No. 2.

Naval Reserve No. 2 includes 30,180.67 acres in the Buena Vista Hills, in the Midway field, Kern County, California.

This reserve was created on December 13, 1912, by order of President Taft, reading as follows:

ORDER OF WITHDRAWAL.

Naval Petroleum Reserve No. 2.

It is hereby ordered that all lands included in the following list and heretofore forming a part of Petroleum Reserve No. 2, California No. 1, withdrawn on July 2, 1910, from settlement, location, sale, or entry, and reserved for classification and in aid of legislation under the authority of the act of congress entitled "An act to authorize the President of the United States to make withdrawals of public lands in certain cases (36 Stat., 847)," shall hereafter, subject to valid existing rights, constitute Naval Petroleum Reserve No. 2 and shall be held for the exclusive use or benefit of the United States Navy until this order is revoked by the President or by act of congress. To this end and for this public purpose, the order of July 2, 1910, is modified and the withdrawal of that date is continued and extended in so far as it affects these lands.

Mt. Diablo Meridian.

T. 31 S., R. 23 E., Secs. 7 to 9, inclusive; Secs. 15 to 18, inclusive; Secs. 20 to 23, inclusive; Secs. 25 to 29, inclusive; Secs. 33 to 36, inclusive.

T. 31 S., R. 24 E., Secs. 30 to 32, inclusive.

T. 32 S., R. 23 E., Secs. 1 to 3, inclusive; Secs. 11 to 13, inclusive.

T. 32 S., R. 24 E., Secs. 2 to 18, inclusive.

T. 32 S., R. 25 E., Sec. 18, all.

WM. H. TAFT,
President.

The status of the land in Naval Reserve No. 2, on December 20, 1916, was as follows:

	Acres
Patented to Southern Pacific Railroad Company (24 sections)	15,394.26
Patented to other parties (5¾ sections)	3,696.68
Pending mineral applications (33)	7,383.60
Vacant and unentered on General Land Office records	3,706.13
Total area (47 sections)	30,180.67

All the land in Naval Reserve No. 2 heretofore patented to the Southern Pacific Railroad Company is included in suits by the federal government asking for cancellation of patents.

Thirteen additional sections, having an additional acreage of approximately 8,320 acres, are included in the so-called withdrawal suits filed by the federal government and hereinafter referred to.

Sixty-three and two-tenths per cent of the area of Naval Reserve No. 2 has heretofore been patented. The acreage is held as follows:

	Acres
Southern Pacific Railroad Company (24 sections)	15,394.26
Standard Oil Company (2¼ sections)	1,440.00
Honolulu Consolidated Oil Company (1¼ sections)	800.00
Associated Oil Company (⅛ section)	80.00
Other parties	1,376.68
Total patented	19,090.94

The status of the 7,383.60 acres affected by pending mineral applications was, on December 20, 1916, as follows:

	Acres
Adverse proceedings directed (20 cases)	4,986.15
Clear listed but not patented, Honolulu Consolidated Oil Co., withdrawal suits	2,077.45
Adverse suit	320.00
Total	7,383.60

Practically the entire area listed as vacant and unentered on the records of the General Land Office, being 3,706.13 acres, is covered with claims and a large portion thereof with wells.

On December 20, 1916, Commissioner Tallman reported to the Special Joint Conference of the Committees on Public Lands of the United States Congress that the wells, acreage and probable petroleum content of Naval Reserve No. 2 were as follows:

Claimant	Producing wells	Dry wells	Total acres	Probable oil lands	Estimated oil content, barrels	Percentage
Kern Trading and Oil Co. (Southern Pacific)	57	10	15,360	9,910	198,800,000	52.4
Other patentees	118	7	3,680	2,550	51,000,000	13.3
Clear listed (Honolulu)	17	3	2,080	1,800	36,000,000	9.4
Unentered	2	16	3,680	220	4,400,000	1.4
Claimed and unpatented	121	17	5,280	4,500	90,000,000	23.5
Totals	315	53	30,080	19,010	380,200,000	100

Commissioner Tallman estimated that of the total assumed petroleum content of 380,200,000 barrels, 80,000,000 barrels have already been extracted.

The most reliable data which this committee has been able to secure from actual reports from the field show that on December 31, 1916, 234 wells inside Naval Reserve No. 2 were producing oil, as contrasted with the 315 wells reported by Commissioner Tallman. The average daily production of these wells was 41,400 barrels.

The relative importance of production in Naval Reserve No. 2 as contrasted with production in the Midway-Sunset field and with the total production in all the oil fields of California is shown by the following comparison, as of December 31, 1916:

	Proved acreage	Daily production in barrels	Number of producing wells	Daily production per well	Daily production per acre	Number of acres per well
Inside Naval Reserve No. 2	18,240	41,400	234	176.9	2.27	78
Midway-Sunset Field, outside Naval Reserve No. 2	38,298	60,817	1,476	41.2	1.59	25.9
All oil fields	108,183	255,983	7,333	34.9	2.37	14.8

In the foregoing computation, the proved acreage includes the territory between the main fields and outlying wells, which is generally considered as "proved."

Referring to Naval Reserve No. 2, Mr. E. B. Latham, expert witness for the government in the withdrawal suits, reports in a letter dated February 15, 1916, to the Secretary of the Navy, in part as follows:

1. This reservation is situated in a proved field where the underground conditions are thoroughly understood.

2. The field may be quickly drilled by rotary tools. Six weeks after commencing drilling the well can be made a producer.

3. Large production is at once available. This is gusher territory.

4. Transportation facilities are ample. Five pipe lines reach three different California coast ports. There are also "ample railroad facilities."

A map attached to this report as Plate VII shows all lands in litigation and also Naval Reserves Nos. 1 and 2 and the lands therein.

III. *Legislation.*

A reference to the most important federal and state legislation affecting California petroleum lands may be helpful.

1. FEDERAL LEGISLATION.

The act of February 11, 1897 (29 Stat. 526) provides that petroleum deposits on the unwithdrawn public domain are acquired under the Placer Law. The act reads as follows:

> "That any person authorized to enter lands under the mining laws of the United States may enter and obtain patent to lands containing petroleum or other mineral oils, and chiefly valuable therefor, under the provisions of the laws relating to placer mineral claims; *provided*, that lands containing such petroleum or other mineral oils which have heretofore been filed upon, claimed, or improved as mineral, but not yet patented, may be held and patented under the provisions of this act the same as if such filing, claim or improvement were subsequent to the date of the passage hereof."

Subsequent to the withdrawal order of September 27, 1909, congress, by act of June 25, 1910 (36 Stat. 847), definitely granted to the President the authority, for public purposes, to make temporary withdrawals of lands of the public domain. The act of June 25, 1910, commonly known as the "Pickett Act," as amended by the act of August 24, 1912 (37 Stat. 497), provides as follows:

> "SECTION 1. That the President may, at any time in his discretion, temporarily withdraw from settlement, location, sale, or entry any of the public lands of the United States including the District of Alaska and reserve the same for water-power sites, irri-

gation, classification of lands, or other public purposes to be specified in the orders of withdrawals, and such withdrawals or reservations shall remain in force until revoked by him or by an act of congress.

"SEC. 2. That all lands withdrawn under the provisions of this act shall at all times be open to exploration, discovery, occupation, and purchase under the mining laws of the United States, so far as the same apply to metalliferous minerals; *provided*, that the rights of any person who, at the date of any order of withdrawal heretofore or hereafter made, is a bona fide occupant or claimant of oil or gas bearing lands and who, at such date, is in the diligent prosecution of work leading to the discovery of oil or gas, shall not be affected or impaired by such order so long as such occupant or claimant shall continue in diligent prosecution of said work; *provided, further,* that this act shall not be construed as a recognition, abridgement, or enlargement of any asserted rights or claims initiated upon any oil or gas bearing lands after any withdrawal of such lands made prior to June twenty-fifth, nineteen hundred and ten; *and provided, further,* that there shall be excepted from the force and effect of any withdrawal made under the provisions of this act all lands which are, on the date of such withdrawal, embraced in any lawful homestead or desert-land entry theretofore made, or upon which any valid settlement has been made and is at said date being maintained and perfected pursuant to law; but the terms of this proviso shall not continue to apply to any particular tract of land unless the entryman or settler shall continue to comply with the law under which the entry or settlement was made; *and provided, further,* that hereafter no forest reserve shall be created, nor shall any additions be made to one heretofore created, within the limits of the states of California, Oregon, Washington, Idaho, Montana, Colorado, or Wyoming, except by act of congress.

"SEC. 3. That the Secretary of the Interior shall report all such withdrawals to congress at the beginning of its next regular session after the date of the withdrawals."

In response to the request of California oil producers that the Secretary of the Interior be given authority to permit the production of petroleum to continue on lands of the public domain pending the determination of the validity of claims of occupants thereto, congress enacted the act of August 25, 1914 (38 Stat. 708), known as the Relief Act, which act amends the act of March 2, 1911, by adding thereto a new section, as follows:

"SEC. 2. That where applications for patents have been or may hereafter be offered for any oil or gas land included in an order of withdrawal upon which oil or gas has heretofore been discovered,

> or is being produced, or upon which drilling operations were in actual progress on October third, nineteen hundred and ten, and oil or gas is thereafter discovered thereon, and where there has been no final determination by the Secretary of the Interior upon such applications for patent, said Secretary, in his discretion, may enter into agreements, under such conditions as he may prescribe with such applicants for patents in possession of such land or any portions thereof, relative to the disposition of the oil or gas produced therefrom or the proceeds thereof, pending final determination of the title thereto by the Secretary of the Interior, or such other disposition of the same as may be authorized by law. Any money which may accrue to the United States under the provisions of this act from lands within the Naval Petroleum Reserves shall be set aside for the needs of the Navy and deposited in the Treasury to the credit of a fund to be known as the Navy Petroleum Fund, which fund shall be applied to the needs of the Navy as congress may from time to time direct, by appropriation or otherwise."

Under an arrangement between the Secretary of the Navy and the Secretary of the Interior, no agreements under this act have been made by the Secretary of the Interior covering any lands within Naval Reserves Nos. 1 and 2.

There is now pending before the federal congress a bill known as H. R. 3232, introduced on April 16, 1917, by Mr. Ferris and commonly known as the "Leasing Bill." This bill undertakes to authorize exploration for and disposition of coal, phosphate, oil, gas, potassium and sodium. Section 12 of the bill reads as follows:

> "That all deposits of oil or gas and the unentered lands containing the same and classified as oil or gas lands, or proven to contain such deposits, except, however, those embraced in any prospecting permit during the life of the same, those patented or for which application for patent by the permittee is pending under the provisions hereof, may be leased by the Secretary of the Interior through competitive bidding under general regulations in areas not exceeding six hundred and forty acres and in tracts which shall not exceed in length two and one-half times their width, such leases to be conditioned upon the payment by the lessee of such royalty as may be fixed in the lease, which shall be not less than one-tenth in amount or value of the production, which royalty on demand of the Secretary of the Interior shall be paid in oil or gas, and the payment in advance of a rental of not less than $1 per acre per annum thereafter during the continuance of the lease, the rental paid for any one year to be credited against the royalties as they accrue

for that year. Leases shall be for a period of twenty years, with the preferential right in the lessee to renew the same for successive periods of ten years upon such reasonable terms and conditions as may be prescribed by the Secretary of the Interior, unless otherwise provided by law at the time of the expiration of such periods; *provided, further,* that upon relinquishment or surrender to the United States, within six months from the date of this act, by any locator or his successors in interest of his or their claim to any unpatented oil or gas lands included in an order of withdrawal, upon which oil or gas had been discovered, was being produced, or upon which drilling operations were in actual progress January first, nineteen hundred and fourteen, and the claim to which land was initiated prior to July third, nineteen hundred and ten, the Secretary of the Interior may, within his discretion, lease, on such reasonable terms and conditions as he may prescribe, to such locator or his successors in interest the said lands so relinquished, not exceeding, however, the maximum area of six hundred and forty acres to any one person, association, or corporation, said leases to be conditioned upon the payment by the lessee of a royalty of not less than one-eighth of the oil or gas extracted or produced from the leased premises or the proceeds thereof, each lease to be for a period of twenty years, with the preferential right in the lessee to renew the same for succeeding periods of ten years, upon such reasonable terms and conditions as may be prescribed by the Secretary of the Interior.''

2. CALIFORNIA LEGISLATION.

By act of June 10, 1915 (Chapter 718, Stat. 1915, p. 1404), the state of California made provision for the appointment of a state oil and gas supervisor, with authority to supervise the drilling, operation, maintenance and abandonment of petroleum or gas wells in the state of California so as to prevent, as far as possible, damage to underground petroleum and gas deposits from the infiltration of water and other causes, and the loss of petroleum or natural gas. Under this statute, persons desiring to drill wells must file an information notice with the oil and gas supervisor. They must take adequate means to shut off water, under the direct supervision of the oil and gas supervisor or a deputy. Wells can not be abandoned unless precautionary measures approved by the oil and gas supervisor have been taken.

The legislature of 1917 passed Senate Bill No. 769, amplifying and strengthening the jurisdiction of the oil and gas supervisor in the prevention of damage to petroleum and gas deposits from the infiltration of water and other causes.

IV. *Litigation.*

Actions filed by the federal government involving California petroleum lands are generally grouped as follows:

1. Southern Pacific suits.
2. Withdrawal suits.

1. Southern Pacific Suits.

The federal government has filed seven suits involving the so-called Southern Pacific lands. The basis of these suits is the claim that the Southern Pacific Railroad Company secured its patents to these lands through fraud.

One suit, known as Case No. 221, involving approximately 6,400 acres, of which 6,109.17 acres are located in Naval Reserve No. 1, was decided in favor of the government on August 9, 1915. This case is now pending on appeal before the United States Circuit Court of Appeals for the Ninth Circuit.

The other six suits involve approximately 166,000 acres, of which amount approximately 156,000 acres are owned directly or indirectly by the Southern Pacific Company, the remaining acreage having been sold to third parties. These six suits have been consolidated for hearing and decision and the testimony has been concluded.

These seven suits together involve all the oil lands owned by the Southern Pacific Company in the state of California with the exception of one section in the Kern River field and a small acreage in the McKittrick field.

2. Withdrawal Suits.

Up to July 1, 1917, the federal government had filed 71 so-called withdrawal suits, affecting a total acreage of approximately 13,180 acres. Of this acreage, 10,980 acres are located in the Midway field, 1,120 acres in the Lost Hills field and 1,080 in the Sunset field.

Two quarter sections, containing 320 acres, are located in Naval Reserve No. 1 and 51 quarter sections, containing approximately 8,160 acres, are located in Naval Reserve No. 2.

These suits all affect lands included in the withdrawal order of September 27, 1909. Each of these suits is based on one or both of the following claims:

1. That the claimants are not bona fide occupants and claimants of the lands in the diligent prosecution on September 27, 1909, of work leading to the discovery of oil or gas or that they did not, subsequent to September 27, 1909, continue in diligent prosecution of said work.

2. That the claimants hold under dummy entrymen.

The defendants in these actions are in part producing companies, in part marketing or purchasing companies and in part locators and other possible claimants.

Table 5 shows in each instance the number of the withdrawal suit, the name of the first defendant, the land affected, the producing company or companies, the purchasing company or companies, whether the land is located in one of the two naval reserves, and whether it is being operated by a receiver under court order.

TABLE
Withdrawal

Number of suit	Name of first defendant	Land
47	Midway Northern Oil Co.	N.W. ¼ Sec. 32, T. 12 N., R. 23 W., S.B.M.
A-2	Consolidated Midway Oil Co.	Fractional Sec. 30, T. 12 N., R. 23 W., S.B.M.
A-3	American Oilfields Co., Ltd.	S.E. ¼ Sec. 32, T. 12 N., R. 23 W., S.B.M.
A-12	G. W. McCutchen	S.W. ¼ Sec. 32, T. 12 N., R. 23 W., S.B.M.
A-13	David Kinsey	S.W. ¼ Sec. 4, T. 11 N., R. 23 W., S.B.M.
A-30	Midland Oilfields Co., Ltd.	N.E. ¼ Sec. 32, T. 12 N., R. 23 W., S.B.M.
A-31	Associated Oil Co.	S.W. ¼ Sec. 26, T. 30 S., R. 23 E., M.D.M.
A-34	Brookshire Oil Co.	S.E. ¼ Sec. 24, T. 31 S., R. 22 E., M.D.M.
A-35	Brookshire Oil Co.	N.E. ¼ Sec 24, T. 31 S., R. 22 E., M.D.M.
A-36	Brookshire Oil Co.	N.W. ¼ Sec. 24, T. 31 S., R. 22 E., M.D.M.
A-37	Devil's Den Cons. Oil Co.	N.E. ¼ Sec. 30, T. 26 S., R. 21 E., M.D.M.
A-38	Thirty-two Oil Co.	N.E. ¼ Sec. 32, T. 31 S., R. 23 E., M.D.M.
A-39	Chanslor-Canfield Midway Oil Co.	S.W. ¼ Sec. 25, T. 31 S., R. 22 E., M.D.M.
A-41	Record Oil Co.	N.E. ¼ Sec. 28, T. 31 S., R. 23 E., M.D.M.
A-42	Consolidated Mutual Oil Co.	N.W. ¼ Sec. 28, T. 31 S., R. 23 E., M.D.M.

5.
Suits.

Producing companies	Purchasing companies	Naval reserve	Receiver
Maricopa Northern Oil Co.; Midway Northern Oil Co.; National Pacific Oil Co.	General Petroleum Corp.; Standard Oil Co.	--------	Receiver
Panama Oil Co.; National Pacific Oil Co.; Whitaker, Doan & Laymance.	Standard Oil Co.; General Petroleum Corp.	--------	Receiver
Midland Oilfields Co., Ltd.; Trojan Oil Co.; California Amalgamated Oil Co.; National Pacific Oil Co.; Miocene Oil Co.; El Dora Oil Co.	General Petroleum Corp.; Standard Oil Co.; Independent Oil Producers Agency.	--------	Receiver
General Petroleum Corp.; Obispo Oil Co.; Spreckels Oil Co.; Maricopa Star Oil Co.; Pacific Midway Oil Co.	General Petroleum Corp.; Standard Oil Co.; Independent Oil Producers Agency; National Oil Co.	--------	Receiver
Union Oil Co.; Midway Fields Oil Co.	Union Oil Co.; Standard Oil Co.	--------	Receiver
Midland Oilfields Co., Ltd.---------	Union Oil Co.------------	--------	Receiver
No production --------------------	----------------------	No. 1	Receiver
Brookshire Oil Co.; United Oil Co.	Standard Oil Co.---------	--------	Receiver
Brookshire Oil Co.-----------------	Standard Oil Co.; General Petroleum Corp.	--------	Receiver
Brookshire Oil Co.; Coalinga-Monterey Oil Co.; Midway Pacific Oil Co.	Standard Oil Co.; General Petroleum Corp.	--------	Receiver
Devil's Den Cons. Oil Co.----------	Associated Oil Co.; Standard Oil Co.	--------	Receiver
California Midway Oil Co.; Buick Oil Co.; Associated Oil Co.	Associated Oil Co.; Standard Oil Co.	--------	Receiver
Chanslor-Canfield Midway Oil Co.; Recovery Oil Co.	Standard Oil Co.---------	--------	Receiver
Record Oil Co.; Consolidated Mutual Oil Co.	Standard Oil Co.; General Petroleum Corp.; Associated Oil Co.	No. 2	Receiver
Consolidated Mutual Oil Co.; Standard Oil Co.	Standard Oil Co.; General Petroleum Corp.; Associated Oil Co.	No. 2	Receiver

TABLE 5

Withdrawal

Number of suit	Name of first defendant	Land
A-43	Caribou Oil Mining Co.	S.E. ¼ Sec. 28, T. 31 S., R. 23 E., M.D.M.
A-46	General Petroleum Corp.	S.W. ¼ Sec. 32, T. 31 S., R. 24 E., M.D.M.
A-47	St. Helens Petroleum Co., Ltd.	S.E. ¼ Sec. 32, T. 31 S., R. 24 E., M.D.M.
A-48	North American Oil Cons.	All Sec. 2, T. 32 S., R. 23 E., M.D.M.
A-49	Standard Oil Co.	N.W. ¼ Sec. 28, T. 32 S., R. 24 E., M.D.M.
A-52	Lost Hills Mining Co.	N.W. ¼ and S.E. ¼ Sec. 30, T. 26 S., R. 21 E., M.D.M. N.W. ¼, N.E. ¼ and S.W. ¼ Sec. 32, T. 26 S., R. 21 E., M.D.M.
A-53	Rock Oil Co.	S.E. ¼ Sec. 23, T. 31 S., R. 22 E., M.D.M.
A-54	Stockton Midway Oil Co.	S.E. ¼ Sec. 14, T. 31 S., R. 22 E., M.D.M.
A-56	Pioneer Midway Oil Co.	N.E. ¼, N.W. ¼ and S.W. ¼ Sec. 12, T. 31 S., R. 22 E., M.D.M.
A-57	Lost Hills Mining Co.	S.W. ¼ Sec. 18, T. 26 S., R. 21 E., M.D.M.
A-58	Dominion Oil Co.	N.W. ¼ Sec. 15, T. 31 S., R. 22 E., M.D.M.
A-64	Pioneer Midway Oil Co.	N.W. ¼, N.E. ¼ and S.E. ¼, Sec. 18, T. 31 S., R. 23 E., M.D.M.
A-68	Associated Oil Co.	S.W. ¼ Sec. 24, T. 30 S., R. 23 E., M.D.M.
A-70	Union Oil Co.	N.W. ¼ Sec. 34, T. 31 S., R. 23 E., M.D.M.
A-71	Union Oil Co.	S.E. ¼ Sec. 34, T. 31 S., R. 23 E., M.D.M.
A-72	Union Oil Co.	S.W. ¼ Sec. 34, T. 31 S., R. 23 E., M.D.M.
A-73	Union Oil Co.	N.E. ¼ Sec. 34, T. 31 S., R. 23 E., M.D.M.
A-74	Midway Gas Co.	S.W. ¼ Sec. 20, T. 31 S., R. 23 E., M.D.M.

*One hundred acres of Pyramid Oil Co.

†Eighty acres of Rock Oil Co.

—Continued.

Suits.

Producing companies	Purchasing companies	Naval reserve	Receiver
Caribou Oil Mining Co.; California Amalgamated Oil Co., Ltd.	Standard Oil Co.	No. 2	Receiver
General Petroleum Corp.; Boston Pacific Oil Co.	General Petroleum Corp.; Standard Oil Co.	No. 2	Receiver
St. Helens Petroleum Co., Ltd.; Boston Pacific Oil Co.	Union Oil Co.; Standard Oil Co.	No. 2	Receiver
North American Oil Cons.	Union Oil Co.	No. 2	Receiver
Standard Oil Co.; Pyramid Oil Co.	Standard Oil Co.; Union Oil Co.	--------	Receiver *
Universal Oil Co.	Associated Oil Co.	--------	Receiver
Rock Oil Co.; General Petroleum Corp.	Standard Oil Co.; General Petroleum Co.	--------	Receiver †
General Petroleum Corp.: Stockton Midway Oil Co.	General Petroleum Corp.; Standard Oil Co.	--------	Receiver
Midlands Oilfields Co., Ltd.			
No production	------------------------	--------	Receiver
Dominion Oil Co.; Bankline Oil Co.; General Petroleum Corp.	Independent Oil Producers Agency; General Petroleum Corp.		
Midland Oilfields Co., Ltd.	------------------------	No. 2	
No production	------------------------	No. 1	
Union Oil Co.; Associated Oil Co.	Union Oil Co.; Associated Oil Co.	No. 2	
Union Oil Co.; Associated Oil Co.	Union Oil Co.; Associated Oil Co.	No. 2	
Union Oil Co.; Associated Oil Co.	Union Oil Co.; Associated Oil Co.	No. 2	
Union Oil Co.; Associated Oil Co.	Union Oil Co.; Associated Oil Co.	No. 2	
Associated Oil Co.; United Oil Co.	Associated Oil Co.; Standard Oil Co.	No. 2	

TABLE 5
Withdrawal

Number of suit	Name of first defendant	Land
A-75	United Oil Co.	N.W. ¼ Sec. 20, T. 31 S., R. 23 E., M.D.M.
B-1	Associated Oil Co.	N.E. ¼ Sec. 20, T. 31 S., R. 23 E., M.D.M.
B-2	Southern California Gas. Co.	S.E. ¼ Sec. 20, T. 31 S., R. 23 E., M.D.M.
B-3	Standard Oil Co.	N.W. ¼ Sec. 22, T. 31 S., R. 23 E., M.D.M.
B-4	Standard Oil Co.	N.E. ¼ Sec. 22, T. 31 S., R. 23 E., M.D.M.
B-5	Associated Oil Co.	S.E. ¼ Sec. 22, T. 31 S., R. 23 E., M.D.M.
B-6	Southern California Gas Co.	S.W. ¼ Sec. 22, T. 31 S., R. 23 E., M.D.M.
B-7	Standard Oil Co.	N.W. ¼ Sec. 26, T. 31 S., R. 23 E., M.D.M.
B-8	Standard Oil Co.	S.E. ¼ Sec. 26, T. 31 S., R. 23 E., M.D.M.
B-9	Standard Oil Co.	N.E. ¼ Sec. 26, T. 31 S., R. 23 E., M.D.M.
B-10	California Midway Oil Co.	N.W. ¼ Sec. 32, T. 31 S., R. 23 E., M.D.M.
B-11	Consolidated Mutual Oil Co.	S.W. ¼ Sec. 28, T. 31 S., R. 23 E., M.D.M.
B-12	Honolulu Cons. Oil Co.	N.W. ¼ Sec. 4, T. 32 S., R. 24 E., M.D.M.
B-13	Honolulu Cons. Oil Co.	S.W. ¼ Sec. 4, T. 32 S., R. 24 E., M.D.M.
B-14	Honolulu Cons. Oil Co.	S.E. ¼ Sec. 4, T. 32 S., R. 24 E., M.D.M.
B-15	Honolulu Cons. Oil Co.	N.W. ¼ Sec. 6, T. 32 S., R. 24 E., M.D.M.
B-16	Honolulu Cons. Oil Co.	N.W. ¼ Sec. 14, T. 32 S., R. 24 E., M.D.M.
B-17	Honolulu Cons. Oil Co.	N.E. ¼ Sec. 14, T. 32 S., R. 24 E., M.D.M.
B-18	Honolulu Cons. Oil Co.	S.E. ¼ Sec. 14, T. 32 S., R. 24 E., M.D.M.

—Continued.

Suits.

Producing companies	Purchasing companies	Naval reserve	Receiver
Associated Oil Co.; United Oil Co.	Associated Oil Co.; Standard Oil Co.	No. 2	
Associated Oil Co.; United Oil Co.	Associated Oil Co.	No. 2	
Associated Oil Co.; United Oil Co.	Associated Oil Co.; Standard Oil Co.	No. 2	
Standard Oil Co.; Associated Oil Co.	Standard Oil Co.; Associated Oil Co.	No. 2	
Standard Oil Co.; Associated Oil Co.	Standard Oil Co.; Associated Oil Co.	No. 2	
Standard Oil Co.; Associated Oil Co.	Standard Oil Co.; Associated Oil Co.	No. 2	
Standard Oil Co.; Associated Oil Co.	Standard Oil Co.; Associated Oil Co.	No. 2	
Standard Oil Co.; Associated Oil Co.	Standard Oil Co.; Associated Oil Co.	No. 2	
Standard Oil Co.; Associated Oil Co.	Standard Oil Co.; Associated Oil Co.	No. 2	
Standard Oil Co.; Associated Oil Co.	Standard Oil Co.; Associated Oil Co.	No. 2	
California Midway Oil Co.; Associated Oil Co.	Standard Oil Co.; Associated Oil Co.		
Consolidated Mutual Oil Co.; United Oil Co.	Standard Oil Co.; Associated Oil Co.; General Petroleum Corp.	No. 2	
Honolulu Consolidated Oil Co.	Standard Oil Co.	No. 2	
Honolulu Consolidated Oil Co.	Standard Oil Co.	No. 2	
Honolulu Consolidated Oil Co.	Standard Oil Co.	No. 2	
Honolulu Consolidated Oil Co.	Standard Oil Co.	No. 2	
Honolulu Consolidated Oil Co.	Standard Oil Co.	No. 2	
Honolulu Consolidated Oil Co.	Standard Oil Co.	No. 2	
Honolulu Consolidated Oil Co.	Standard Oil Co.	No. 2	

TABLE 5

Withdrawal

Number of suit	Name of first defendant	Land
B-19	Honolulu Cons. Oil Co.	S.W. ¼ Sec. 14, T. 32 S., R. 24 E., M.D.M.
B-20	Honolulu Cons. Oil Co.	S.W. ¼ Sec. 12, T. 32 S., R. 24 E., M.D.M.
B-21	Honolulu Cons. Oil Co.	S.W. ¼ Sec. 6, T. 32 S., R. 24 E., M.D.M.
B-22	Honolulu Cons. Oil Co.	N.E. ¼ Sec. 6, T. 32 S., R. 24 E., M.D.M.
B-23	Honolulu Cons. Oil Co.	S.E. ¼ Sec. 6, T. 32 S., R. 24 E., M.D.M.
B-24	Honolulu Cons. Oil Co.	S.E. ¼ Sec. 8, T. 32 S., R. 24 E., M.D.M.
B-25	Honolulu Cons. Oil Co.	N.W. ¼ Sec. 8, T. 32 S., R. 24 E., M.D.M.
B-26	Honolulu Cons. Oil Co.	S.W. ¼ Sec. 8, T. 32 S., R. 24 E., M.D.M.
B-27	Honolulu Cons. Oil Co.	N.E. ¼ Sec. 8, T. 32 S., R. 24 E., M.D.M.
B-28	Honolulu Cons. Oil Co.	N.W. ¼ Sec. 12, T. 32 S., R. 24 E., M.D.M.
B-35	Standard Oil Co.	S.W. ¼ Sec. 12, T. 32 S., R. 23 E., M.D.M.
B-36	Standard Oil Co.	N.W. ¼ Sec. 12, T. 32 S., R. 23 E., M.D.M.
B-37	Standard Oil Co.	N.E. ¼ Sec. 12, T. 32 S., R. 23 E., M.D.M.
B-38	Standard Oil Co.	S.E. ¼ Sec. 12, T. 32 S., R. 23 E., M.D.M.
B-39	Standard Oil Co.	N.E. ¼ Sec. 18, T. 32 S., R. 24 E., M.D.M.
B-40	Standard Oil Co.	N.W. ¼ Sec. 18, T. 32 S., R. 24 E., M.D.M.
B-42	Associated Oil Co.	N.E. ¼ Sec. 35, T. 31 S., R. 22 E., M.D.M.
B-43	American Oilfields Co., Ltd.	N.E. ¼ Sec. 32, T. 32 S., R. 24 E., M.D.M.
B-44	Brookshire Oil Co.	S.W. ¼ Sec. 24, T. 31 S., R. 22 E., M.D.M.

—Continued.

Suits.

Producing companies	Purchasing companies	Naval reserve	Receiver
Honolulu Consolidated Oil Co	Standard Oil Co	No. 2	
Honolulu Consolidated Oil Co	Standard Oil Co	No. 2	
Honolulu Consolidated Oil Co	Standard Oil Co	No. 2	
Honolulu Consolidated Oil Co	Standard Oil Co	No. 2	
Honolulu Consolidated Oil Co	Standard Oil Co	No. 2	
Honolulu Consolidated Oil Co	Standard Oil Co	No. 2	
Honolulu Consolidated Oil Co	Standard Oil Co	No. 2	
Honolulu Consolidated Oil Co	Standard Oil Co	No. 2	
Honolulu Consolidated Oil Co	Standard Oil Co	No. 2	
Honolulu Consolidated Oil Co	Standard Oil Co	No. 2	
No production		No. 2	
No production		No. 2	
Standard Oil Co	Standard Oil Co	No. 2	
No production		No. 2	
Standard Oil Co	Standard Oil Co	No. 2	
Standard Oil Co	Standard Oil Co	No. 2	
Associated Oil Co	Associated Oil Co.		
American Oilfields Co., Ltd	Standard Oil Co.		
Brookshire Oil Co.; San Francisco Midway Oil Co.	Standard Oil Co.		

We herewith give a brief reference to each reported decision in the California withdrawal suits as well as a reference to the decision of the Supreme Court of the United States in the Midwest Oil Company case. We do not intend to discuss the principles of law established, but merely to state the nature of the decree entered in each case.

In all the California withdrawal suits the government asks relief by bills in equity as follows:

To stay waste;

To preserve the property during the pendency of patent proceedings before the local and general land office;

For the appointment of a receiver;

To remove cloud from the title; and

To recover possession and damages on account of the removal of oil and injury to the oil deposits.

United States vs. *Midway Northern Oil Co. et al.*, Case No. 47, 216 Fed. 802, decided on May 29, 1914, affects the N. W. ¼ of section 32, township 12 north, range 23 west, S. B. M., which land was entered upon subsequent to the withdrawal order of September 27, 1909, for the purpose of exploring for oil. Dooling, District Judge, held that the withdrawal order was void and accordingly dismissed the bill. Subsequent to the decision of the Supreme Court of the United States in *United States* vs. *Midwest Oil Company et al.*, hereinafter referred to, a petition for rehearing herein was granted. See *United States* vs. *Midway Northern Oil Co. et al.*, 238 Fed. 619, 623, 624.

United States vs. *McCutchen et al.*, Case No. A-12, 217 Fed. 650, decided on September 1, 1914, affects the S. W. ¼ of section 32, township 12 north, range 23 west, S. B. M., on which land oil had been discovered. Dooling, District Judge, held that the entire situation was too clouded to warrant the court at that time in disturbing the possession of the operating companies and denied the motion for the appointment of a receiver. The government's motion for the appointment of a receiver was later granted. 234 Fed. 702.

In *United States* vs. *Midwest Oil Company et al.*, 236 U. S. 459, decided on February 23, 1915, involving certain oil lands in Wyoming in which entry was made subsequent to the withdrawal order of September 27, 1909, the United States filed a bill in equity to enjoin operations on the land and for an accounting. The Supreme Court announced that the sole question at issue was the validity of the withdrawal order of September 27, 1909, and held that the order was valid.

El Dora Oil Company vs. *United States*, Case No. A-3, 229 Fed. 946, decided on December 31, 1915, affects the S. E. ¼ of section 32, township

12 north, range 23 west, S. B. M. The Circuit Court of Appeals affirmed an order granting a preliminary injunction and appointing a receiver.

United States vs. *Midway Northern Oil Co. et al.*, Consolidated Cases Nos. 47, A-2, A-3, A-13, A-30 and A-31, 232 Fed. 619, decided on May 1, 1916, affects the following land: In Case No. 47, N. W. ¼ of section 32, township 12 north, range 23 west, S. B. M.; in Case No. A-2, fractional section 30, township 12 north, range 23 west, S. B. M.; in Case No. A-3, S. E. ¼ of section 32, township 12 north, range 23 west, S. B. M.; in Case No. A-13, S. W. ¼ of section 4, township 11 north, range 23 west, S. B. M.; in Case No. A-30, N. E. ¼ of section 32, township 12 north, range 23 west, S. B. M.; and in Case No. A-31, S. E. ¼ of section 26, township 30 north, range 23 west, S. B. M. Discoveries of oil were all made subsequent to the withdrawal order of September 27, 1909. Bean, District Judge, dismissed the bills with respect to the marketing companies without prejudice to the right of the government to sue at law, if it should so elect. The court assigned the cases to a master to ascertain and report the sums due from the defendants to the government, such sums to be computed on principles laid down in the decision. The court indicated that upon the coming in of the master's report a decree would be entered ousting the operating companies from their possession and restoring possession to the government.

United States vs. *McCutchen et al.*, Case No. A-12; *United States* vs. *Kinsey et al.*, Case No. A-13, and *United States* vs. *Midland Oilfields Co. et al.*, Case No. A-30, 234 Fed. 702, decided on July 12, 1915, affect the following lands: In Case No. A-12, S. W. ¼ of section 32, township 12 north, range 23 west, S. B. M.; in Case No. A-13, S. W. ¼ of section 4, township 11 north, range 23 west, S. B. M.; and in case No. A-30, N. E. ¼ of section 32, township 12 north, range 23 west, S. B. M. Bledsoe, District Judge, granted motions of the government for injunctions to stay waste and for the appointment of receivers.

United States vs. *Devil's Den Consolidated Oil Company et al.*, Case No. A-37; *United States* vs. *Lost Hills Mining Company et al.*, Case No. A-52, and *United States* vs. *Lost Hills Mining Company et al.*, Case No. A-57, 236 Fed. 973, decided on October 4, 1916, affect oil lands in the Lost Hills field as follows: In Case No. A-37, N. E. ¼ of section 30, township 26 south, range 21 east, M. D. M.; in Case No. A-52, N. W. ¼ and S. E. ¼ of section 30 and N. W. ¼, N. E. ¼ and S. W. ¼ of section 32, township 26 south, range 21 east, M. D. M.; and in Case No. A-57, S. W. ¼ of section 18, township 26 south, range 21 east, M. D. M. Bean, District Judge, appointed a receiver for all the land affected except the south ½ of section 22.

United States vs. *McCutchen et al.*, Case No. A-12, 238 Fed. 575, decided on July 29, 1916, affects S. W. ¼ of section 32, township 12 north, range 23 west, S. B. M. Bledsoe, District Judge, directed the master to report upon all oil produced from the property and purchased by the marketing companies, whereupon the court will make its further order.

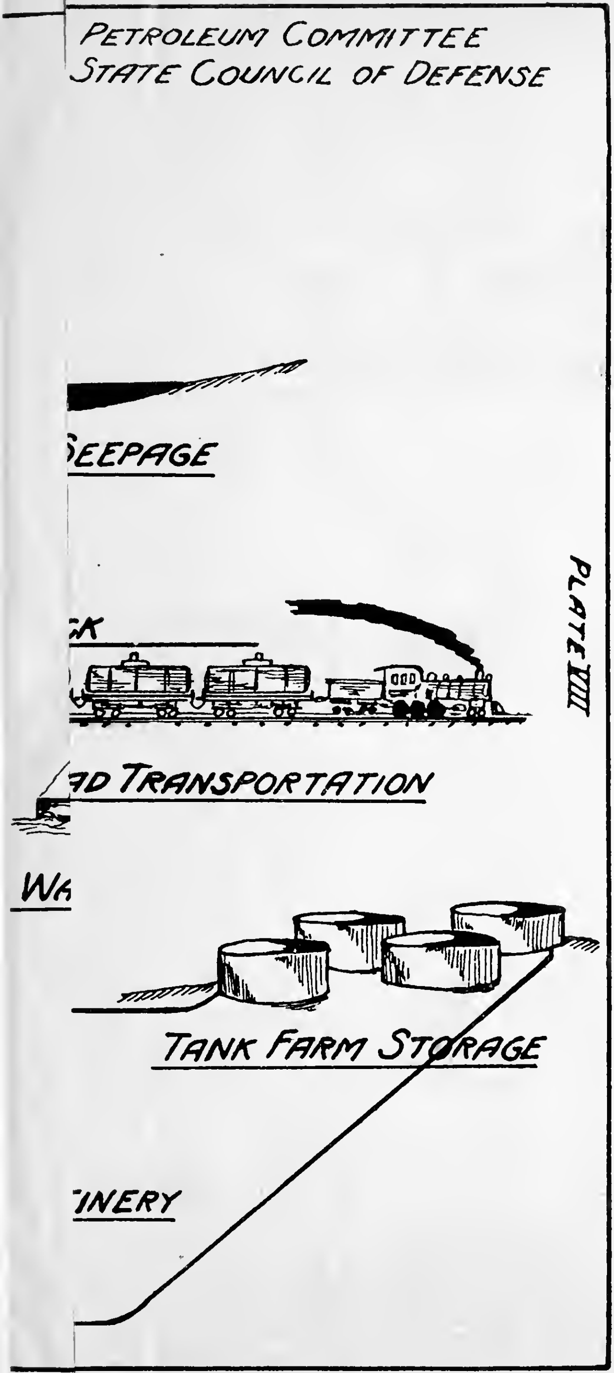
United States vs. *Stockton Midway Oil Company et al.*, Case No. A-54, 240 Fed. 1006, decided on January 5, 1917, affects S. E. ¼ of section 14, township 31 south, range 22 east, M. D. M. Bledsoe, District Judge, granted the motions of the government for an injunction in restraint of waste and for the appointment of a receiver.

United States vs. *Brookshire Oil Company et al.*, Case No. A-34; *United States* vs. *Brookshire Oil Company et al.*, Case No. A-35, and *United States* vs. *Brookshire Oil Company et al.*, Case No. A-36, decided on June 7, 1917, affect the S. E. ¼, the N. E. ¼ and the N. W. ¼, respectively, of section 24, township 31 south, range 22 east, M. D. M. Bean, District Judge, held that these three quarter sections of land had been located by dummy entrymen and that the government was entitled to a decree enjoining the defendants from committing waste. He further held that the plaintiff being admittedly out of possession, a decree quieting title could not be entered in an equity proceeding. Judge Bean dismissed the proceedings with reference to the marketing or producing companies.

United States vs. *Thirty-two Oil Company et al.*, Case No. A-38, decided on June 7, 1917, affects the N. E. ¼ of section 32, township 31 south, range 21 east, M. D. M. Bean, District Judge, held that this was also a case of dummy entrymen and that the defendants did not bring themselves within the provisions of the Pickett Act. Judge Bean held that the government was entitled to a decree enjoining waste except as to the marketing or producing companies and a number of defendants who had parted with their interests in the property prior to the commencement of the suit.

United States vs. *Record Oil Company et al.*, Case No. A-41; *United States* vs. *Consolidated Mutual Oil Company et al.*, Case No. A-42, and *United States* vs. *Caribou Oil Mining Company et al.*, Case No. A-43, decided on June 7, 1917, affect the N. E. ¼, the N. W. ¼ and the S. E. ¼, respectively, of section 28, township 31 south, range 21 east, M. D. M. This property is located in Naval Reserve No. 2. Judge Bean drew attention to the fact that final certificate had been issued by the Registrar of the Land Office in these cases and that the issue of patent is now pending before the Department of the Interior, and concluded that under these circumstances the federal court was without jurisdiction. He accordingly directed that these three proceedings be dismissed.

United States vs. *North American Oil Company et al.,* Case No. A-48, decided on June 11, 1917, affects section 2, township 32 south, range 23 east, M. D. M. Bean, District Judge, found that the predecessors of the defendants now claiming the land brought themselves within the provisions of the Pickett Act; that work leading to discovery had been prosecuted with necessary diligence both before and after the withdrawal order of September 27, 1909, until discovery was made on each of the four quarter sections of land involved and that the bill should be dismissed. Judge Bean, in this case, established certain principles which will be of signal importance in a number of other withdrawal suits now pending. The land affected is located in Naval Reserve No. 2.



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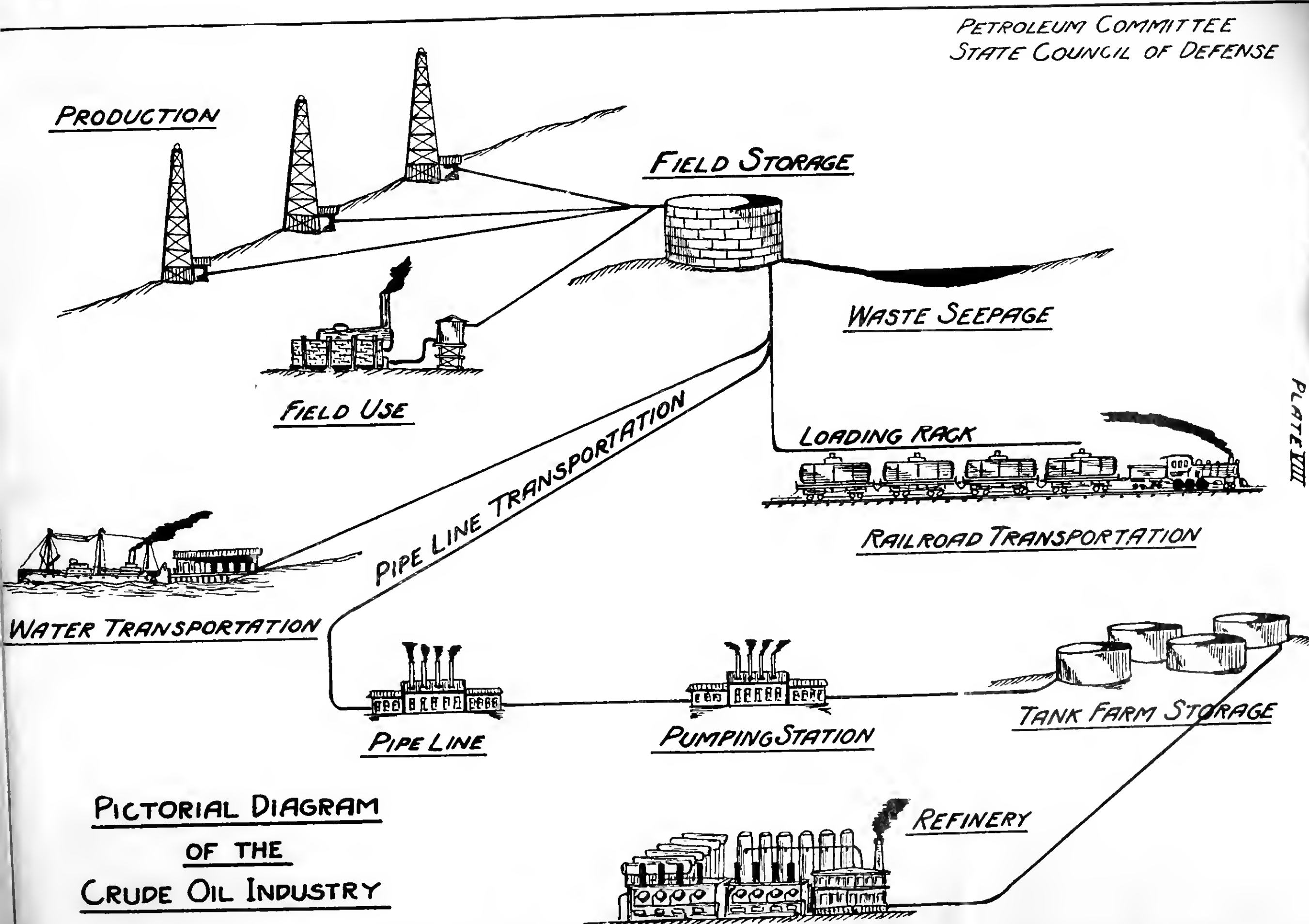
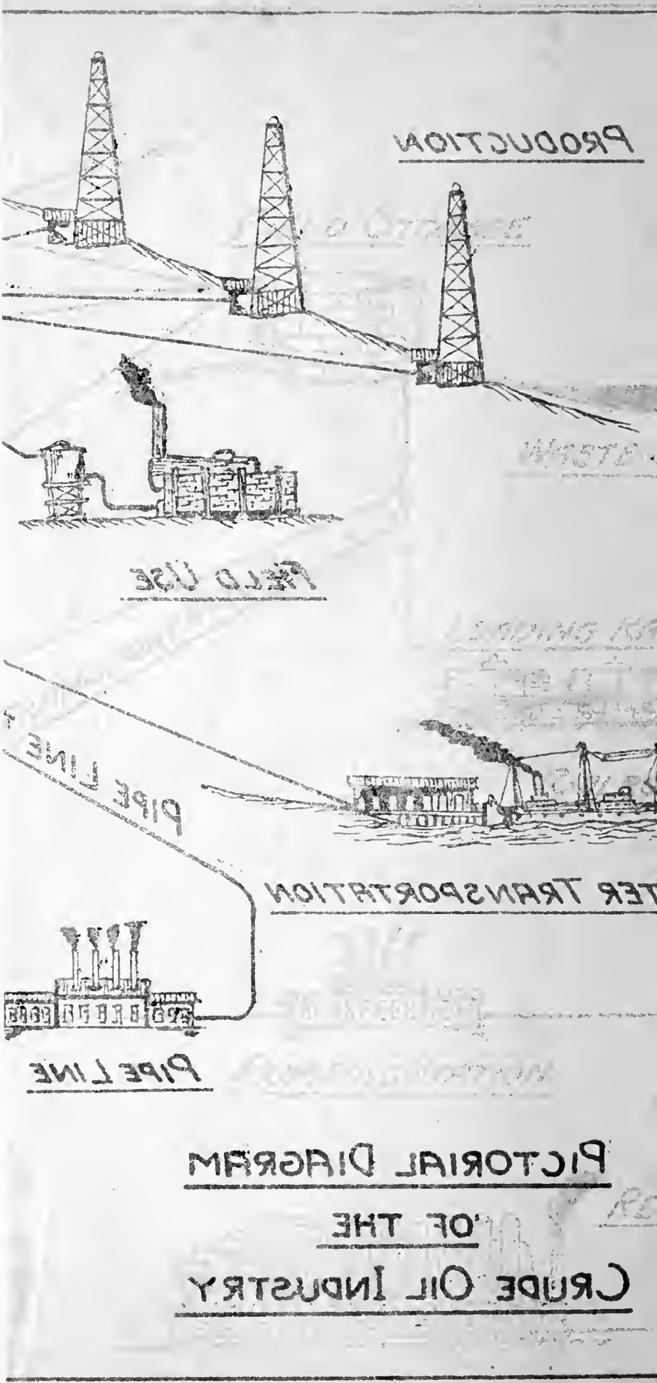


PICTORIAL DIAGRAM
OF THE
CRUDE OIL INDUSTRY


PRODUCTION
FIELD USE
PIPE LINE
TER TRANSPORTATION
PIPE LINE
PICTORIAL DIAGRAM
OF THE
CRUDE OIL INDUSTRY

CHAPTER IV.

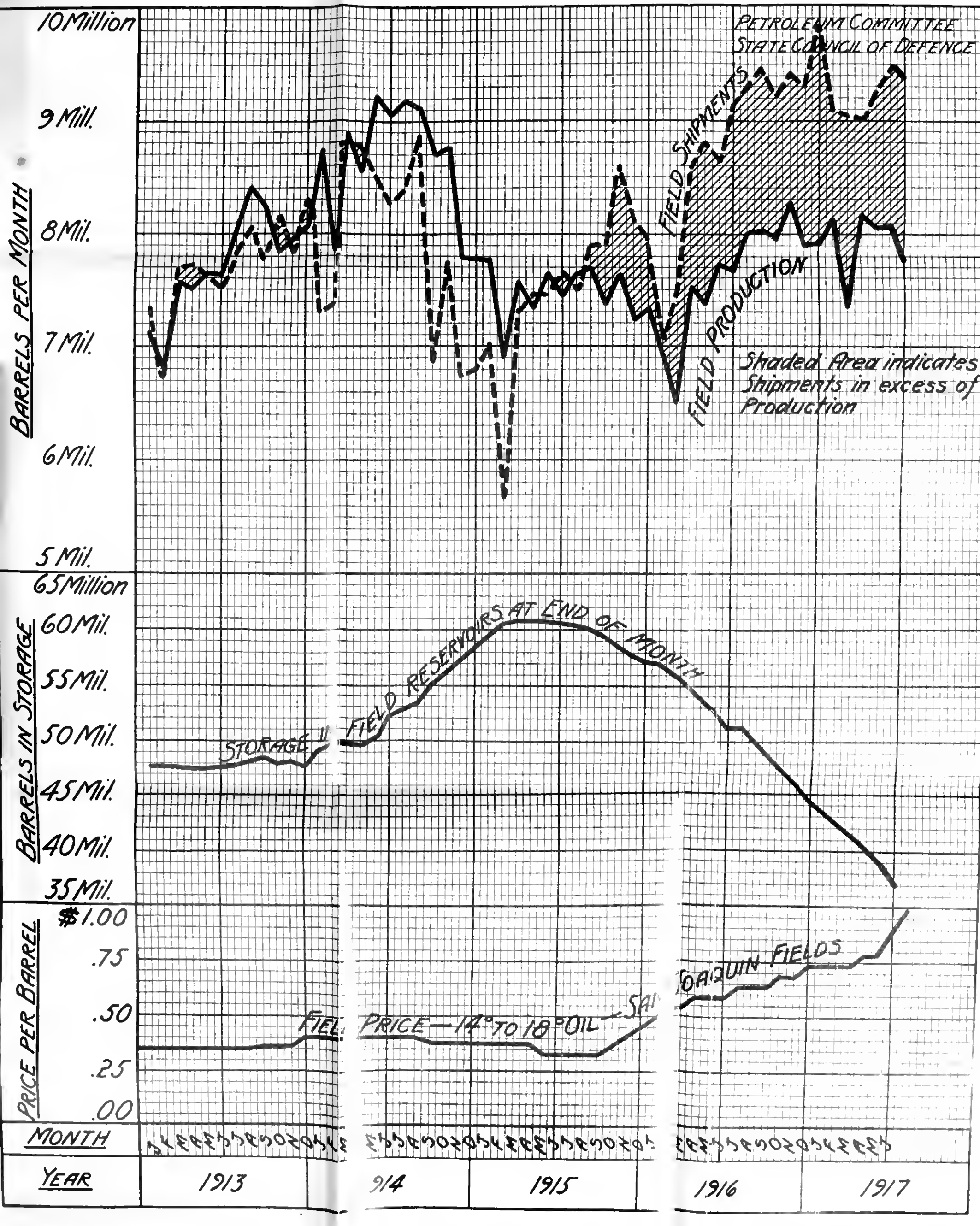
at all the oil produced in any given period of time can be accounted
r in that same period. In that respect, the movement of oil, as
own in Plate VIII, may be compared to a great river system with

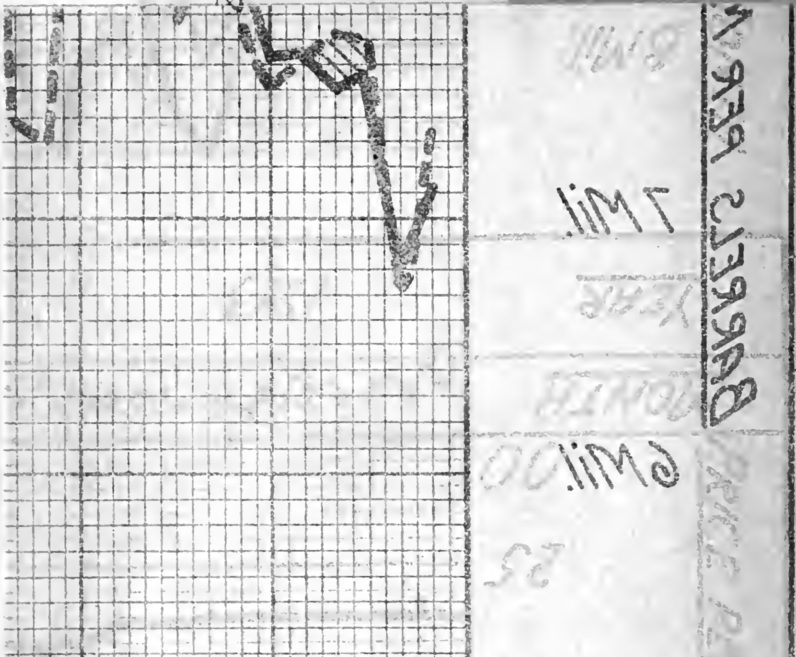
PLATE IX

PRODUCTION, SHIPMENTS, STORAGE AND PRICE

CALIFORNIA CRUDE OIL

JANUARY 1913–JUNE 1917




BARRELS PER
7 Mil.
6 Mil.
5 Mil.
65 Million
60 Mil.
55 Mil.
50 Mil.
STORAGE

CHAPTER IV.

PRODUCTION OF CALIFORNIA PETROLEUM.

I. *General Statement.*

1. Discussion of Statistics.

In this chapter and the four following chapters statistics of the California oil industry will be considered in detail. First, as a basis for estimating the future production, the recent output of various districts will be compared; and finally, as a gauge of future demand, the past utilization of oil will be shown. In this investigation the controlling factor to be recognized in a study of production is the availability of the oil, which includes the relative difficulty of both production and distribution to point of use.

The production of crude oil from the fields of California has been carefully recorded for years by marketing companies of the state and by the California State Mining Bureau. However, the analysis of these published figures has rarely been attempted by anyone outside of the oil industry, and the interpretation by the oil producers of their own production statistics has not always been correct. This is not surprising, in view of the fact that the history of the oil business in America shows rapid changes, and the discovery of new fields and the sudden exhaustion of pools has often upset forecasts of production and price.

2. Definitions of Production Terms.

Before taking up the discussion of detail, some definition of terms of production is required. In these statistical chapters, *gross production* will be used to designate a total quantity of oil brought to the surface of the ground. *Production* will indicate the net quantity remaining after field consumption and loss are deducted from gross production. This will be the amount shipped from the field in pipe lines or tank cars. The term *delivered production* will be applied to the quantity of oil delivered by pipe lines to the refineries and reshipment ports, together with tank car shipments from the fields. This quantity will equal the difference between net production and pipe line consumption and loss.

The relation between the present gross production and the utilization is shown in Plate XXVI.

3. Necessary Assumptions.

For the purpose of this report, it is necessary to make the assumption that all the oil produced in any given period of time can be accounted for in that same period. In that respect, the movement of oil, as shown in Plate VIII, may be compared to a great river system with

many tributary streams and many reservoirs and diversion canals through which the water is distributed for use before it is finally discharged into the ocean through a delta. The constant change in production and demand for oil has the same effect as the seasonal variation on the flow and use of water, and not only the storage stocks, but the oil in the pipe lines and in the process of manufacture forms a reserve with constantly fluctuating level, which prevents an actual exact balance between production and utilization.

As a matter of fact, the exact measure of oil produced in any period is impossible. This is partly due to the fact that all oil is sold and measured with an allowable 3 per cent of water and sediment. For this reason the statistical figures in this report are in most instances given to the nearest 10,000 barrels, and, for the purpose of comparison, it is assumed that in any period the quantity of oil utilized can be determined by taking into account, first, the quantity produced; second, the amount used or wasted in the industry itself, and third, the variation in the quantity in storage.

II. *Present Production.*

The present gross production is approximately 8,000,000 barrels of oil per month. In addition to this, an average of 1,100,000 barrels per month has been drawn from storage in the last year and a half. The quantity of oil used in the fields in drilling and pumping amounts to approximately 260,000 barrels per month. The amount used in the pumping stations along the pipe lines, together with the wastage of oil through seepage and evaporation, is estimated at 210,000 barrels per month, while the quantity burned under the stills of the various refineries is approximately 260,000 barrels per month.

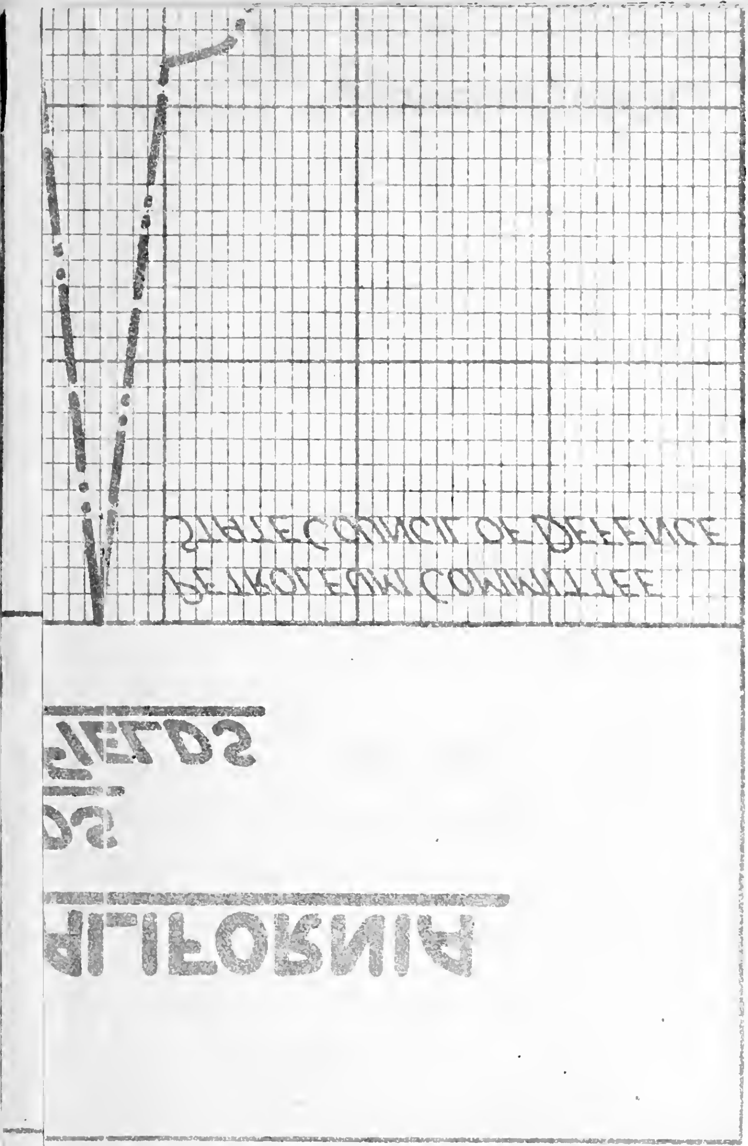
The net amount of oil utilized is, therefore, 8,370,000 barrels, of which amount 7,000,000 barrels are burned under boilers, as fuel oil, and the balance, 1,370,000, is distributed as various refined products.

The general description of the oil fields of the state and the history of their production is given in Chapter III. The relation between supply and demand and price is shown in Plate IX, and requires but little comment. The change from the overproduction of 1914 to the present shortage, with the corresponding increase in price paid in the field, are the most prominent features to be noted.

III. *Production by Districts.*

In Table 6 and in Plates X and XI the actual production of the principal fields of the state is shown. This classification of fields is the one usually followed, but in order to simplify the figures and at the same time bring out certain features in regard to the state's produc-

tivity, a grouping of these fields into districts is shown in Table 7 and in Plate XII.



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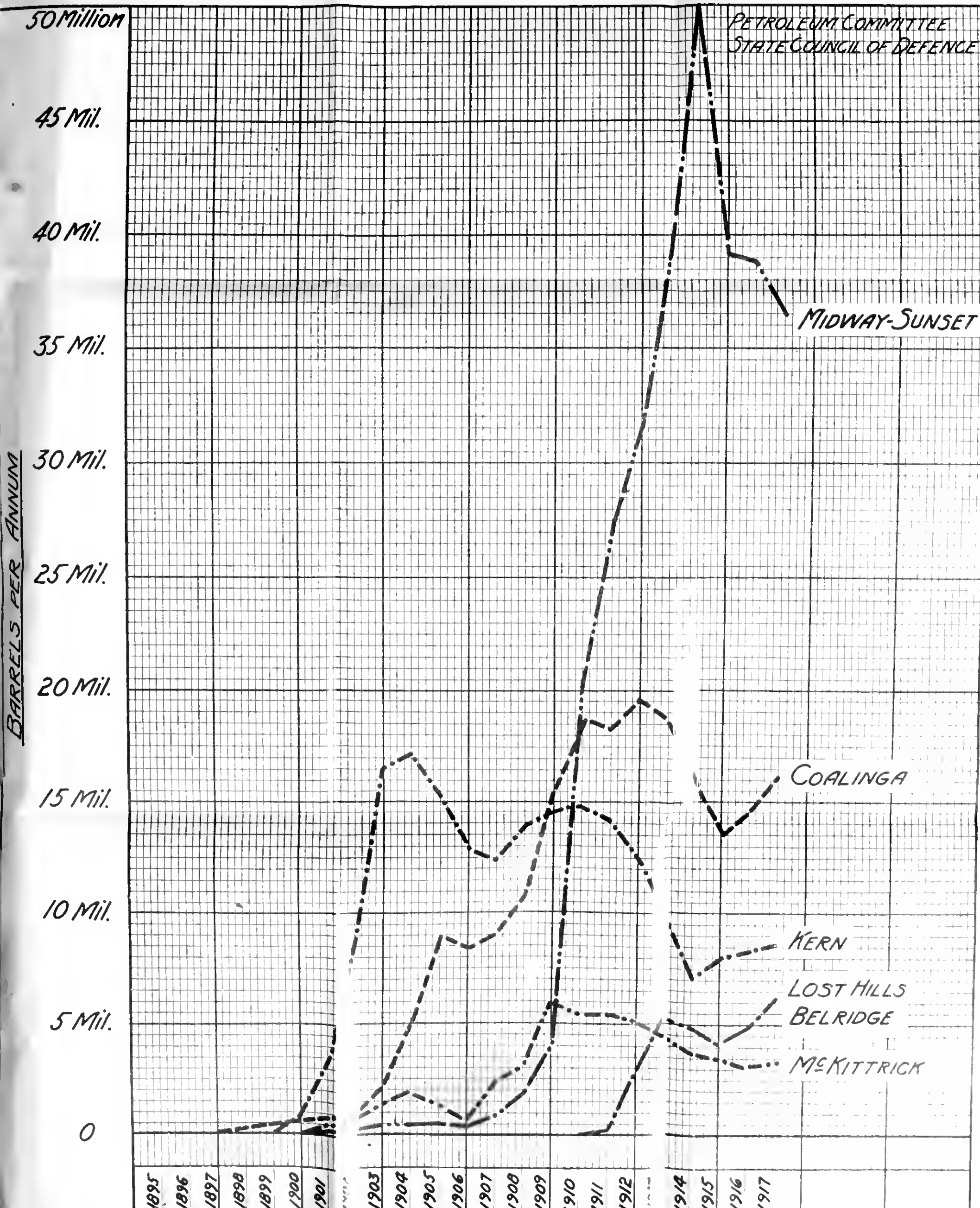
increasing. This oil is almost entirely refined and only the residuum is used as fuel.

PRODUCTION OF CRUDE OIL IN CALIFORNIA

SAN JOAQUIN VALLEY FIELDS
ANNUAL OUTPUT IN BARRELS BY FIELDS



many tributary streams and m ls

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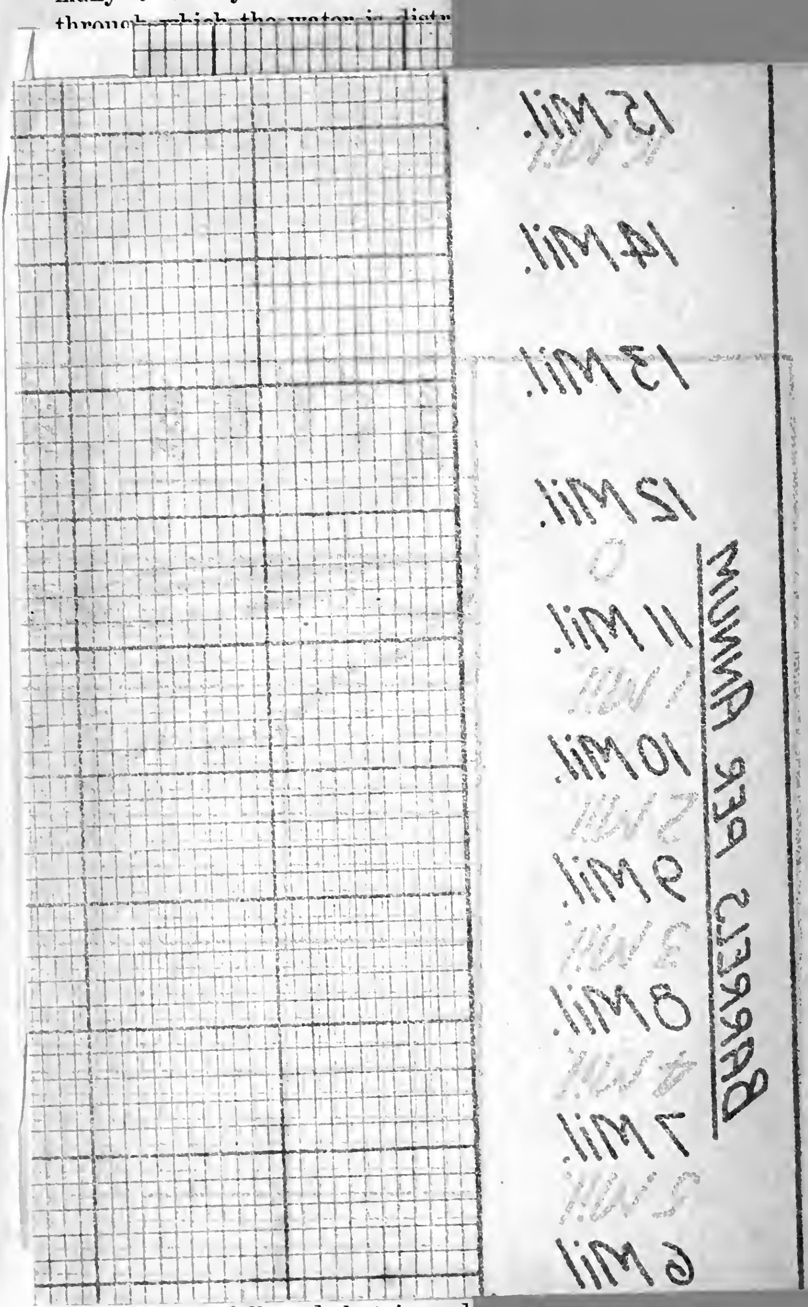


one usually followed, but in ord

same time bring out certain feat

tivity, a grouping of these fields into districts is shown in Table 7 and in Plate XII.

The fields on the west side of the San Joaquin Valley form a geographic unit where the essential features of development and transportation are alike, since the productive area is separated from the main line of railroads by sparsely-settled territory and from tide water by mountain ranges. This group of fields has produced as high as three-fourths of the state's annual output and is now maintaining two-thirds of California's production. Approximately 47 per cent of the present producing wells of the state and 60 per cent of the present drilling are in this area. Nearly all the flowing wells of the state are in this district, and Plates XIV and XXXIII, showing the present production per well per day for each field, expresses their relative importance. As stated in Chapter III, there is a wide range of gravity in the oil from this district. At the present time, approximately 60 per cent of the production is sent to refineries of the state for treatment, and a greater amount even of the heavier oil now sold direct for fuel contains a large percentage of lubricating stock which could and should be recovered.

The Kern River field is in a favorable natural location for supplying fuel oil to railroads, but must ship through long pipe lines or over long rail routes to supply other markets. As shown in Plate X, the production of this field declined rapidly between 1911 and 1914. Since the latter date the output has slightly increased, due to the stimulant of the rising price of crude oil and the opening and pumping of wells. At the present time one-quarter of the producing wells of the state are in this field, but the output is only 9 per cent of the state's total. A few wells are now being drilled in the western extension of this field, in territory only partially proven. The oil from this district is heavy and is used almost entirely for fuel purposes.

The Whittier-Fullerton district includes a number of small pools which are fully developed and are producing only small quantities of oil, and also includes the Coyote and Montebello areas, with large outputs per well and rich possibilities for the future. The district is in an ideal location for the supply of local southern California markets, is close to tide water and to the trunk lines of the railroads for supplying locomotive fuel or oil for shipment to the interior points, but is dependent upon vessel shipment to reach the northern California or northwestern market. Taken as a whole, this district maintains about one-sixth of the present state output of crude oil from 8 per cent of the producing wells. Approximately one-fifth of the present drilling wells of the state are in this area, and the monthly production is steadily increasing. This oil is almost entirely refined and only the residuum is used as fuel.

The Southern Coast district, as arbitrarily established, includes the Los Angeles, Salt Lake and scattered Ventura fields. The majority of the wells are in a favorable location as regards distribution of the oil to market, but the small pools included in the district are either so widely scattered or so nearly exhausted as to play a relatively unimportant part in the industry of the state. Only one-fortieth of the present state output comes from this district, which includes nearly 15 per cent of the producing wells. The maximum production of this district was reached in 1908, and a steady decline has followed since that date. Approximately one-half of this oil is sent directly to refineries and the balance is used as fuel and road oils.

The Central Coast area is easily tributary to tidewater and steamer transportation, but is largely dependent upon tankers for the ultimate distribution of the oil.

Table 7 and Plate XI show the relative importance of this area and its present production. The Santa Maria field has declined steadily since 1908, but extensive development is now being carried on in new territory adjacent to the old pools. The greater part of the oil produced here is sold directly as fuel, but plans are being executed to refine a greater proportion in the future.

IV. *Analysis of Production Figures.*

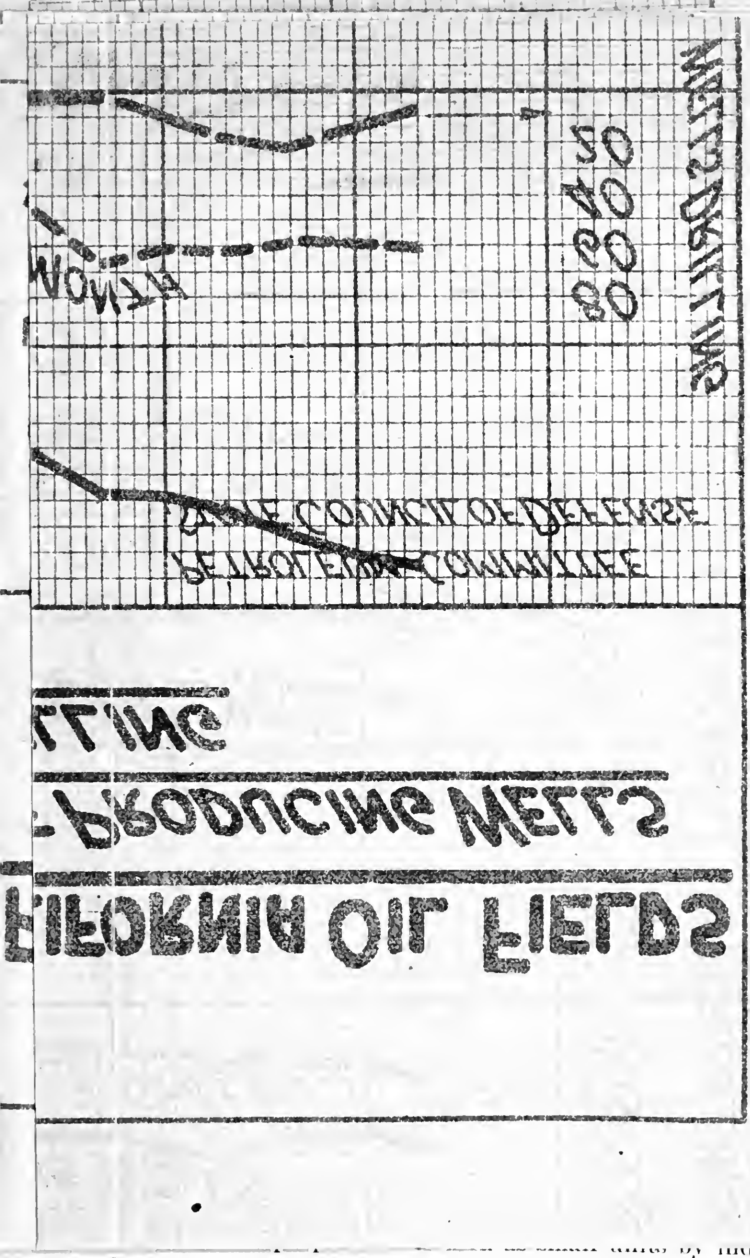
The total production of the state is shown in Table 6 and the character of the oil produced in Plate XV.

The change in the character of the oil produced in California is due to the decline in the output in the Kern River fields and the rapid increase in production of the Midway-Sunset district, following the discovery of oil in Buena Vista Hills and Sunset Flat in 1909, and the development in Coyote Hills since 1913.

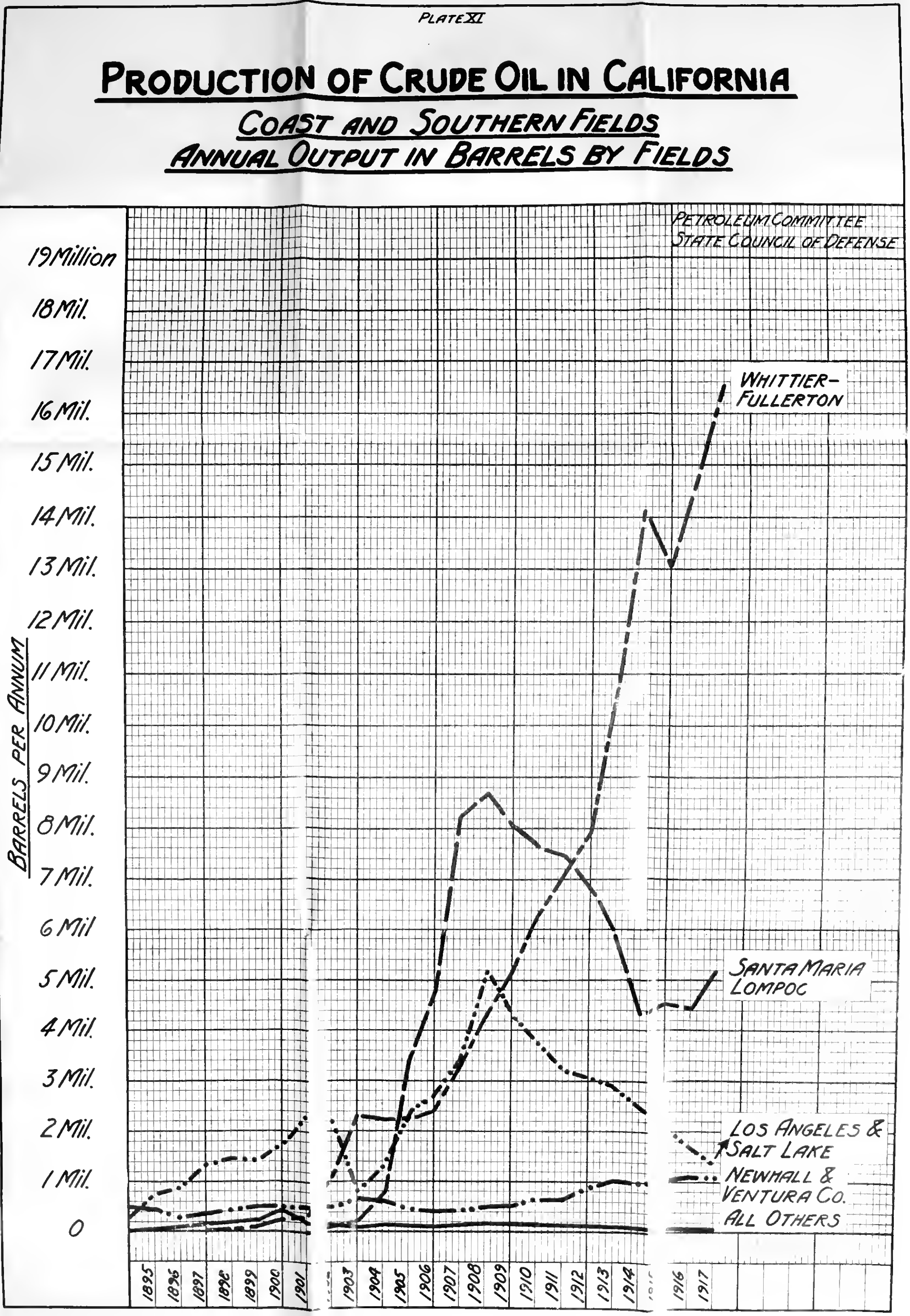
A study of the curves in Plates X and XI will show that the Whittier-Fullerton and Lost Hills-Belridge are the only important areas where the production curve has not crossed its peak. The East Coalinga field in the West San Joaquin district is now increasing its output, owing to a very intensive drilling campaign, but on account of the decline of old wells it is not probable that production from this district will ever reach the high-water mark of 1912. In the Midway-Sunset field, which is the most productive area in the state, the decline in production is very rapid.

The outstanding fact in regard to the output of petroleum of California is the monthly decline of production, well by well, throughout all the fields. Plate XIII, prepared by the Appraisal Committee of the Independent Oil Producers' Agency and published through the courtesy of this agency, shows this fact very clearly.

The obvious fact that each new producing well in a district adds to the difficulty of maintaining production is not clearly recognized by the public which is unfamiliar with the records of decline of oil wells. It



individual owners. This is largely due to the fact that expensive installations of pipes and gas compressors are required to separate and handle the gas


PRODUCTION OF CRUDE OIL IN CALIFORNIA
COAST AND SOUTHERN FIELDS
ANNUAL OUTPUT IN BARRELS BY FIELDS
PETROLEUM COMMITTEE
STATE COUNCIL OF DEFENSE
19 Million
18 Mil.
17 Mil.
16 Mil.
15 Mil.
14 Mil.
13 Mil.
12 Mil.
11 Mil.
10 Mil.
9 Mil.
8 Mil.
7 Mil.
6 Mil
5 Mil.
4 Mil.
3 Mil.
2 Mil.
1 Mil.
0
BARRELS PER ANNUM
WHITTIER-FULLERTON
SANTA MARIA LOMPOC
LOS ANGELES & SALT LAKE
NEWHALL & VENTURA CO.
ALL OTHERS
1895
1896
1897
1898
1899
1900
1901
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
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1914
1916
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the wells are in a favorable loc ... o
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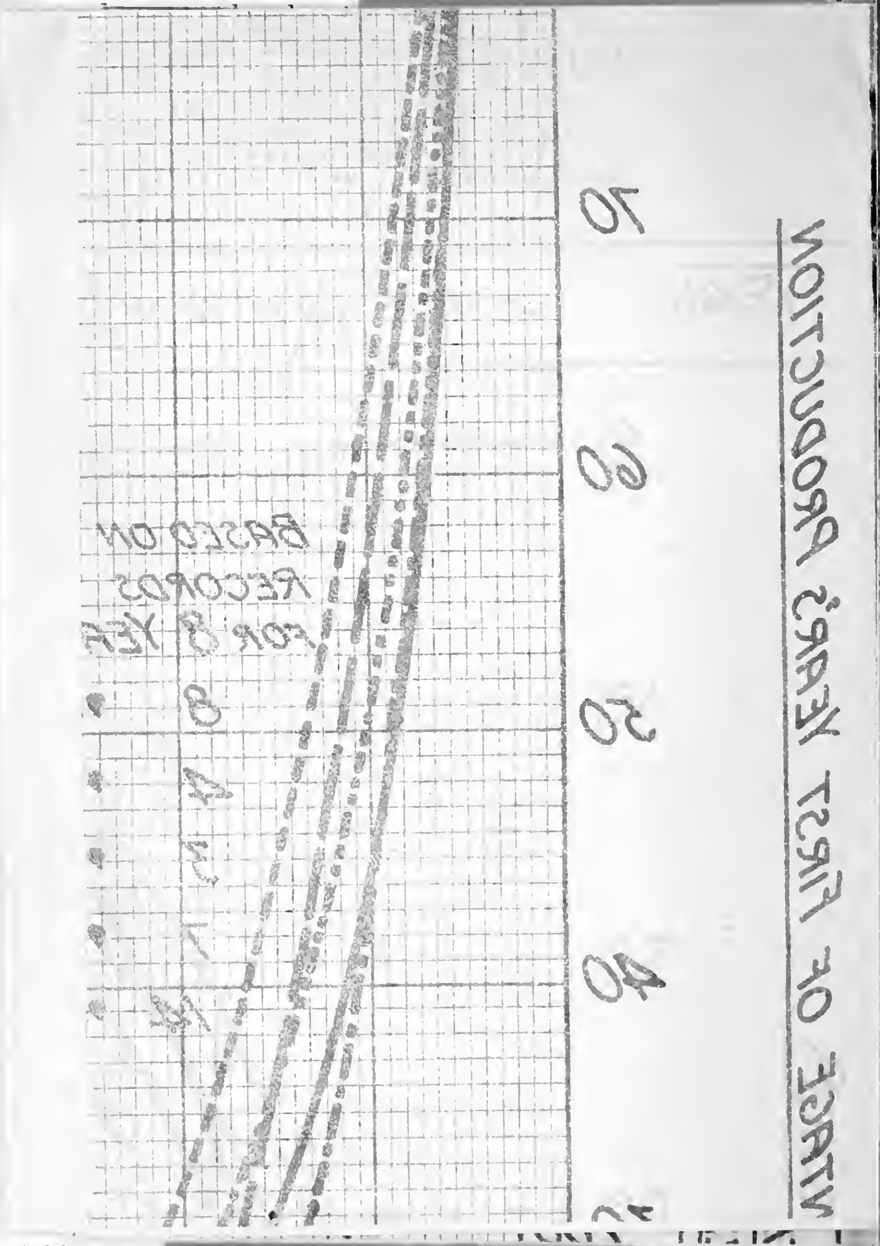

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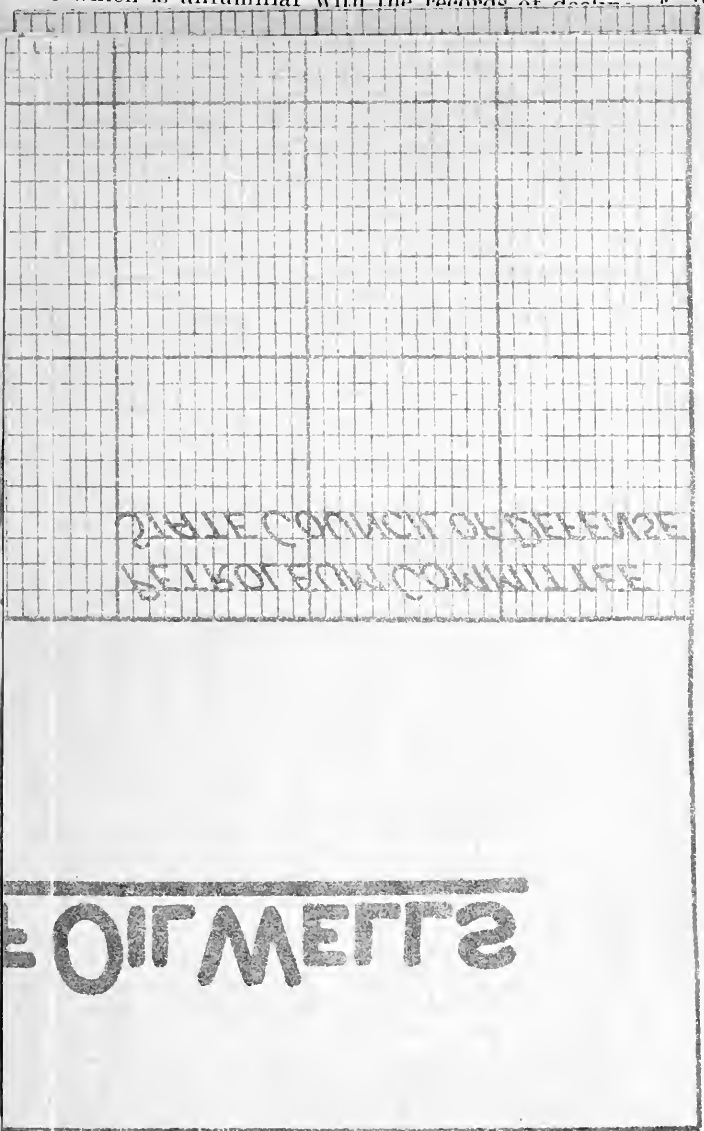
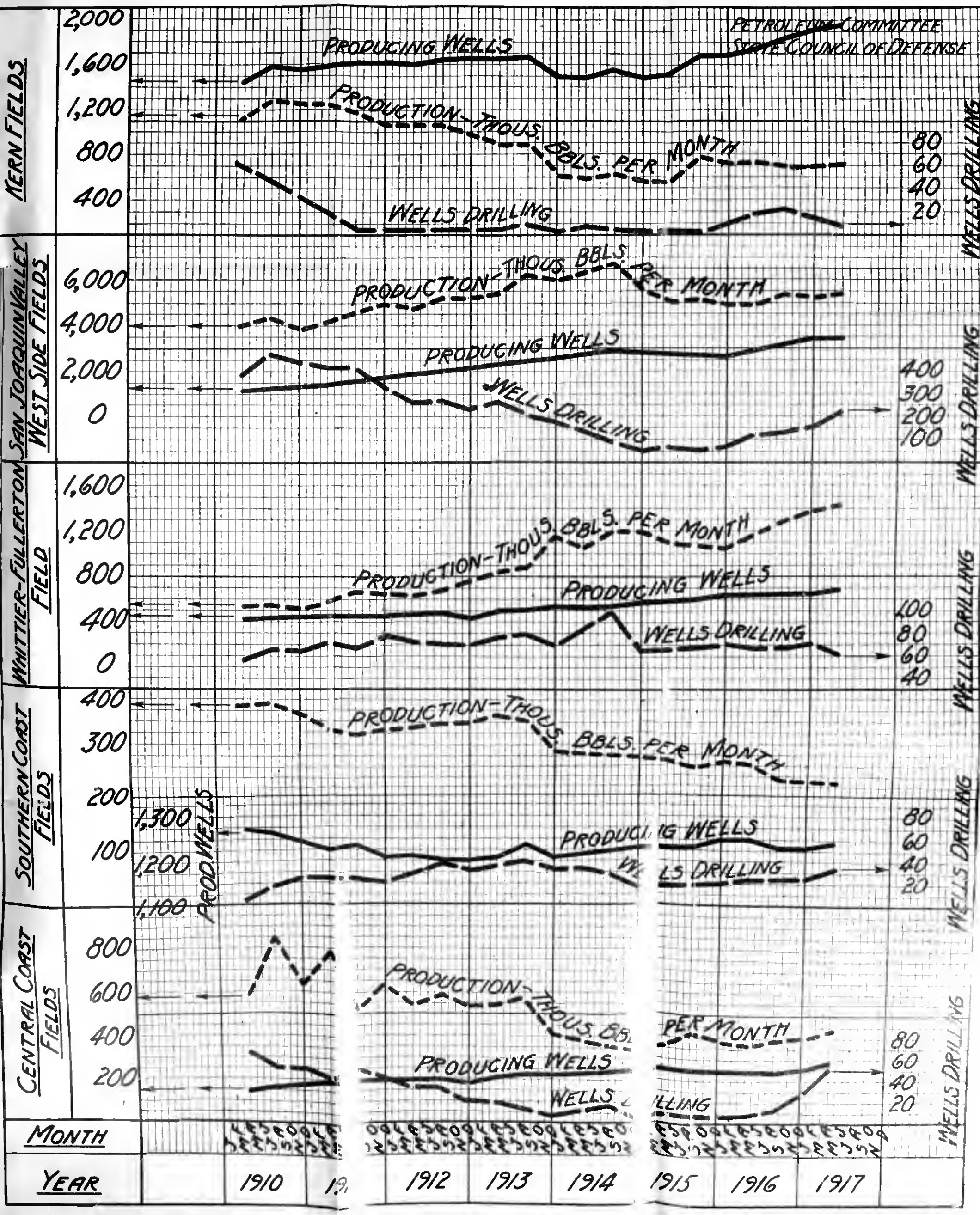


field loss is on the properties handled as small units by individual ers. This is largely due to the fact that expensive installations of es and gas compressors are required to separate and handle the gas

Plate XII

Production and Development of California Oil Fields

Showing Output of Wells, Number of Producing Wells and Number of Wells Drilling



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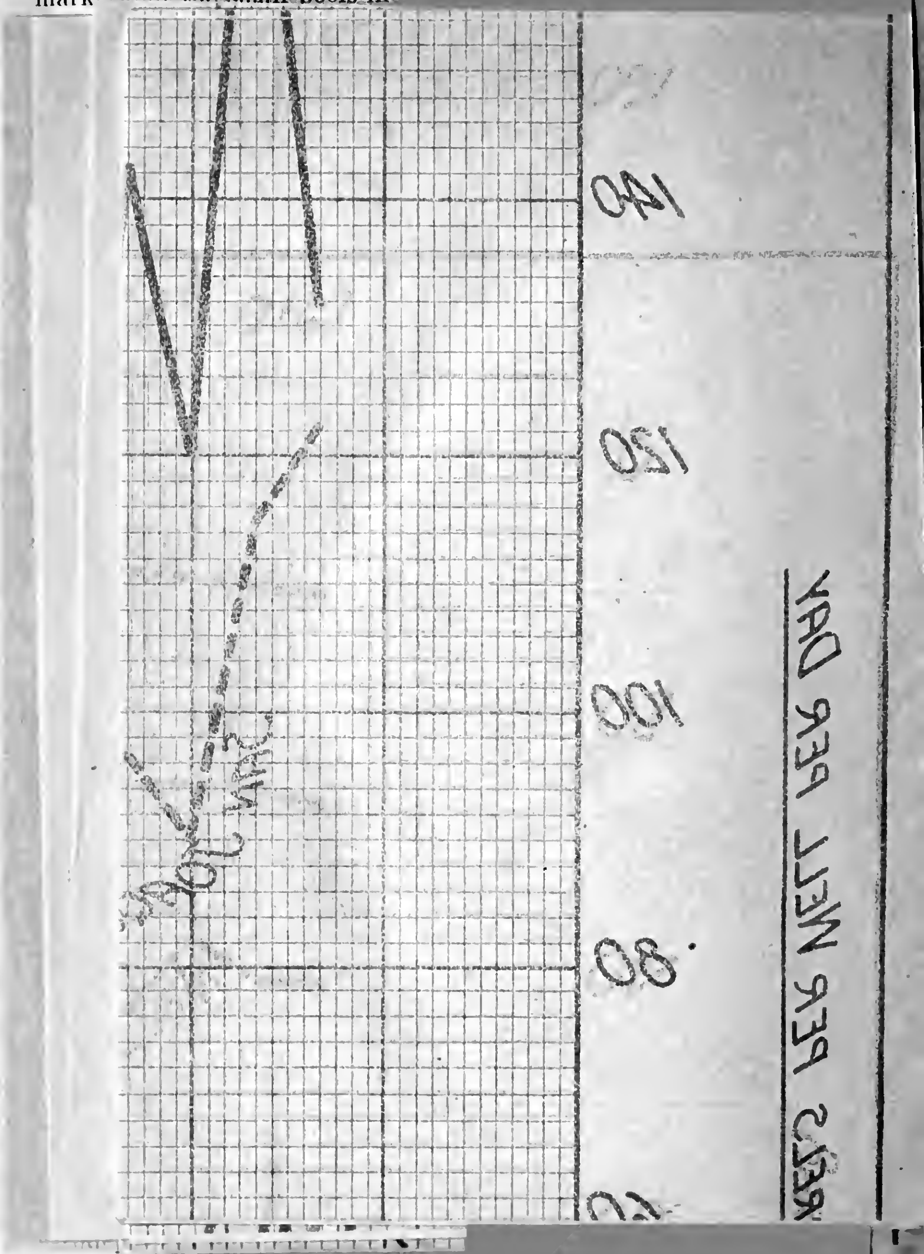

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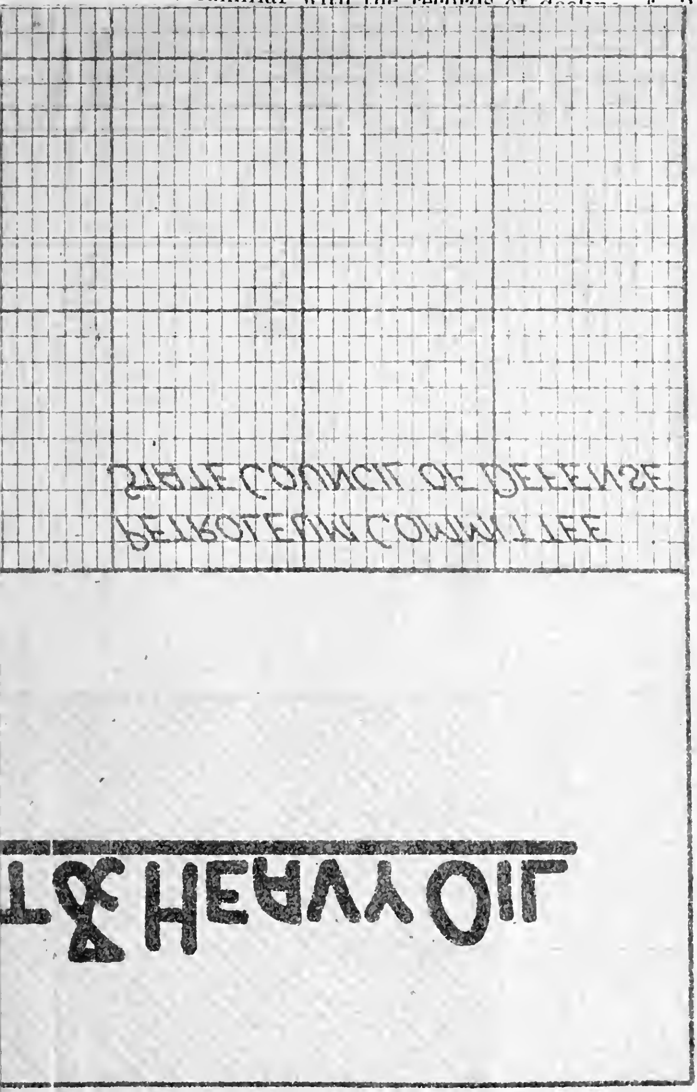

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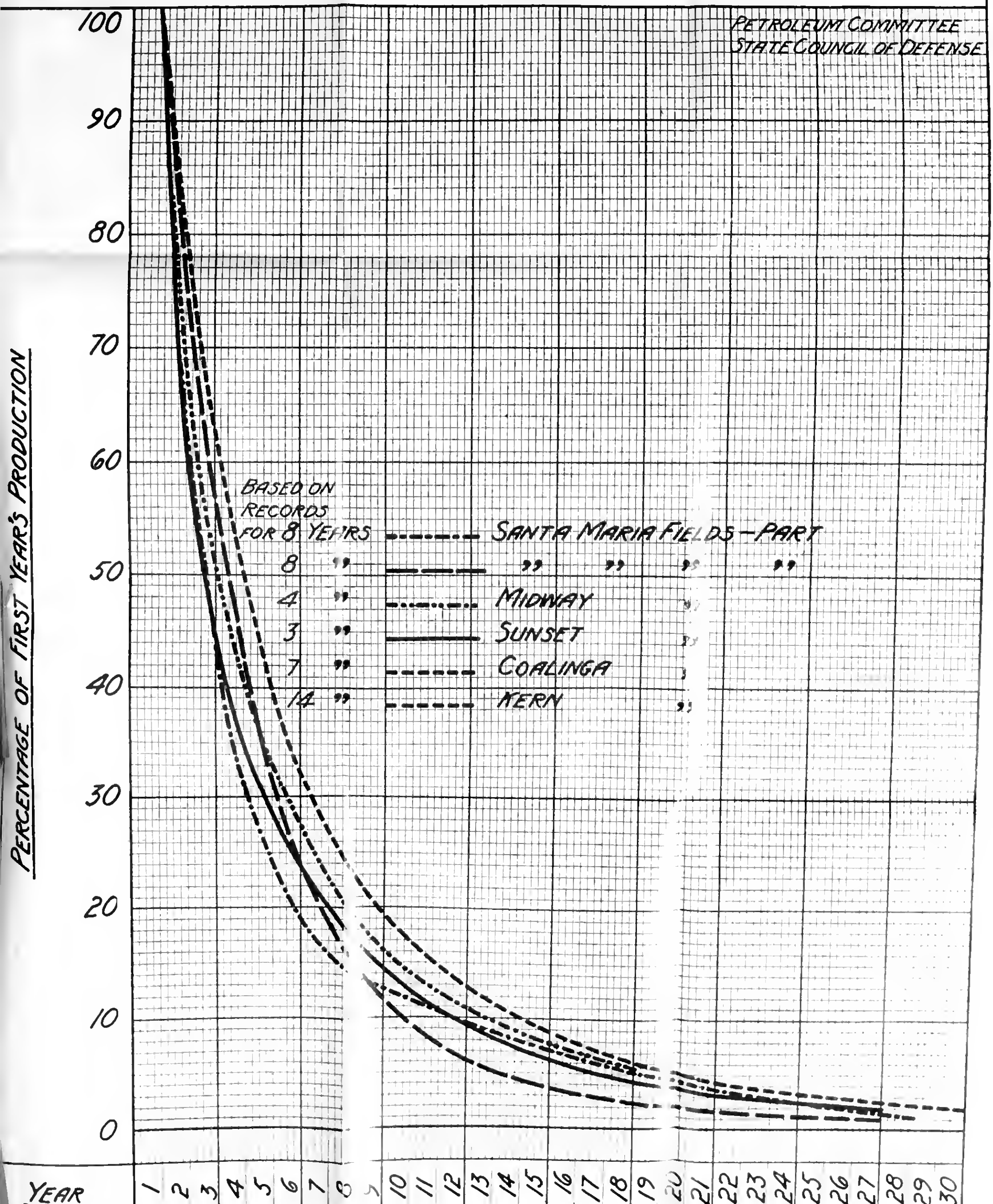
PLATE XIII

DECLINE IN PRODUCTION

AVERAGE WELLS

CALIFORNIA FIELDS



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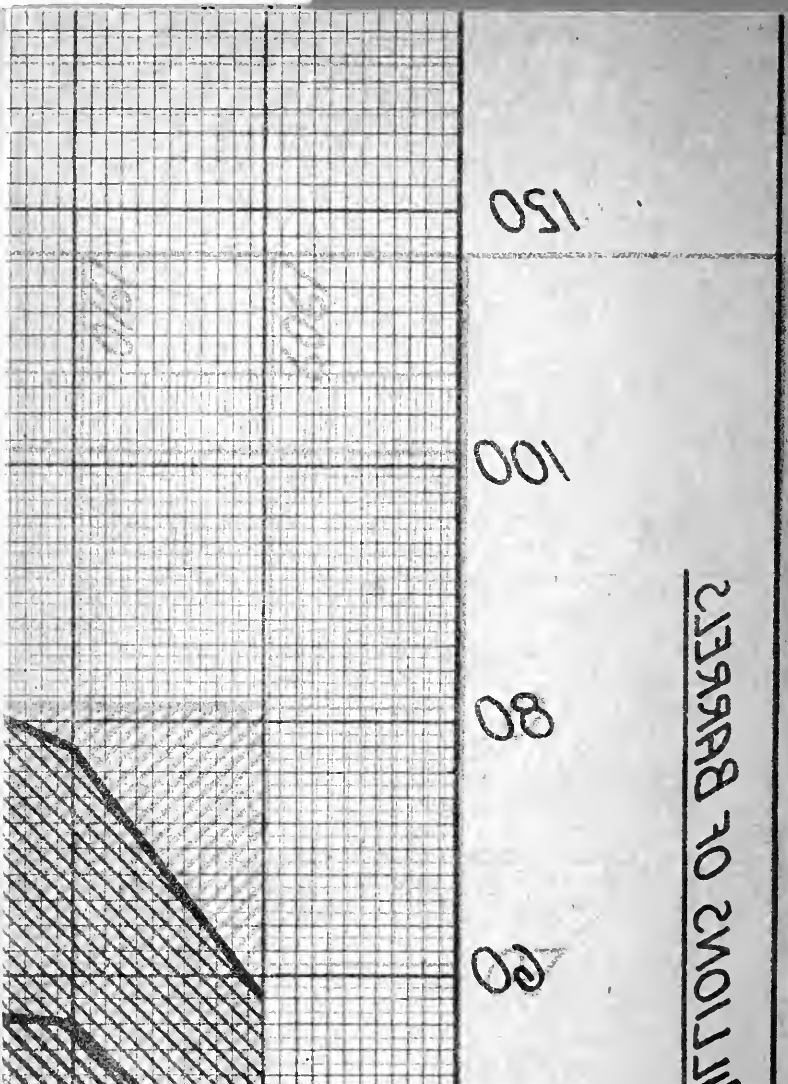

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The obvious fact that each new producing well in a district adds to the difficulty of maintaining production is not clearly recognized by the public which is unfamiliar with the records of decline of oil wells. It is an axiom with the producers, however, and for California the drilling requirements to meet the demands of production can be worked out with almost mathematical precision if a large territory is considered. This will be further discussed in Chapter X, and at this point it is only necessary to note the fact that the number of producing wells in each district has steadily grown, and that a much greater increase in the number of wells will be required to make a material change in the quantity of oil produced.

V. *Control of Oil Lands and Production.*

1. Advantage of Operation of Large Units.

The oil lands in the State of California, and consequently the production, are very largely under the control of the large marketing companies. If a more complete control of small areas and the small operating companies had been possible in the past, the overproduction of 1913 and 1914 could have been checked and the present shortage would not be so acute and could be faced with greater security. There can be no question as to the need of a large amount of capital and a through the comparison of accurately reported logs.
thorough organization to handle the many problems of the oil industry.

Some of the advantages of the operation of oil lands in large units, which are familiar to those engaged in field operations, are:

First—The opportunity for careful study of drilling problems

Second—The protection of the oil sands from water, by reason of a uniform policy of development.

Third—Economical drilling campaigns resulting in fewer wells, by eliminating the necessity of offset wells.

Fourth—An efficient and well organized technical staff.

Fifth—The opportunity for providing adequate storage and transportation facilities.

Sixth—The relative ease of developing adequate water supply.

Seventh—The economy of fuel and the conservation of the oil produced.

Even the most superficial inspection of the California oil fields will convince anyone that the relatively greater efficiency of the larger producing companies as compared with the individual producers has saved a great quantity of oil and a large sum of money to the state of California. As an example, the greater part of the field consumption and field loss is on the properties handled as small units by individual owners. This is largely due to the fact that expensive installations of pipes and gas compressors are required to separate and handle the gas

produced with the oil, and such an installation is only practical where large quantities are handled.

It should be borne in mind that the large companies are, by reason of their greater resources, under moral obligation to do more efficient work than the smaller competitors and that the state and nation should look to these companies to set the pace in the matter of intelligent conservation of oil.

In the maintenance of production the drilling of lands in large tracts is especially important. Approximately two-thirds of the oil now produced in California comes from lands owned by five large oil companies, and 60 per cent of the producing wells and of the wells being drilled in May, 1917, were on their lands.

In Plate XXXX the recent drilling in the state is shown and the comparative figures show clearly the present attempt to increase production.

The amount of money required to conduct extensive drilling, especially at the present prices of material and labor, can be judged from the following figures.

The cost of completing an oil well in California varies throughout the districts with the depth and conditions of drilling. It may be anywhere from $10,000 to $100,000, and as an average figure in a proved territory, the estimate of $10 to $15 per foot has been used by some companies. At the present prices of material, these estimated costs would be nearly doubled, so that a well 3,000 feet in depth might be expected to cost from $50,000 to $80,000.

The following data have been obtained by summarizing and averaging the detailed reports and estimates made by one of the larger companies in 1914, the basis of these reports being the normal price of material and labor prevailing in the various fields at that time. The present prices of materials are approximately 80 to 100 per cent higher, and of labor 40 to 50 per cent higher than in 1914; hence, the figures in the tables given below should be raised in these proportions to represent the present conditions. No attempt has been made to adjust the figures to present prices for the reason that during the present unsettled state of affairs, quotations and wages are and will be subject to fluctuations for some time to come.

Standard tools alone are usually used for drilling wells less than 1,900 feet in depth in all fields in the San Joaquin Valley, in the Whittier-Fullerton and Coast districts at a cost of equipment ranging from $2,200 to $2,800 per well.

Rotary tools, in combination with standard tools, are usually used for drilling wells greater than 1,900 feet in depth in all fields in the San Joaquin Valley and in the Whittier-Fullerton District, the rotary

being used for the greater part of the depth and the Standard tools being used to finish the well and drill into the oil sand. The cost of the combination rotary and standard equipment ranges from $3,000 to $3,600 per rig.

The cost of drilling wells may be conveniently considered under three heads:

1. Surface equipment per well, which varies, in a general way, with the method of drilling and depth, and only in a minor way with the cost of material in the various fields. A few standards of surface equipment are sufficient for all cases. Given the field, the method of drilling and the general depth of the well, the proper standard is easily selected.

2. Underground equipment, which varies, in a general way, with the number of feet of depth, as well as the character of formation encountered in drilling in the different fields; and only in a minor way with the cost of material in the various fields, as well as the method of drilling employed.

3. Operating tools, which vary, in a general way, with the number of days necessary to drill a given well, as well as the method of drilling employed, and in a minor way with the cost of material and labor in the various fields. All the labor employed in drilling is included under this head.

The example given herewith shows the cost of drilling a well in the Midway field 3,300 feet deep by the combination method, assuming the rotary tools to be stopped at 3,220 feet. This includes the cost per day of operating the tools for the different methods and the number of days necessary to drill the well to the given depth with standard tools and with rotary tools.

Combination surface equipment for depths greater than 2,300 feet, San Joaquin Valley	$3,600 00
Combination underground equipment for Sunset-Midway District, 3,300 feet at $4.29 per foot	14,157 00
Operating tools—	
Rotary, 3,220 feet requires 171 days:	
For Sunset-Midway District, 171 days at $107.65	18,408 00
Standard—Time for 3,220 feet, 267 days	
Time for 3,300 feet, 277 days	
Difference 80 feet, 10 days	
Plus 10 days	
For Sunset-Midway District 20 days at $55.65	1,113 00
Total estimated cost of well	$37,278 00

At the present time, approximately 370 wells are being drilled in the state. Of these, 92, or approximately one-fourth, are owned by one company, which is expending each month over $400,000 on this development work and is using material purchased at a lower price than that now quoted by the supply companies. On this basis, the present campaign for oil is costing operators of the state about $20,000,000 a year.

The amount of money expended in drilling in the five years from 1912 to 1916, inclusive, can be estimated from the following figures:

	Number	Total depth, feet	Average depth, feet
Producing wells completed	2,572	4,848,639	1,885
Abandoned wells	506	1,075,807	2,126

Assuming a cost of $10.00 per foot for drilling complete, the total cost of these wells was approximately $60,000,000. It is worthy of note that approximately one-fifth of the wells drilled in this period were failures.

The hazard of the oil business can be judged from the above ratio, which applies to a period when the structural features of the oil fields of the state were well understood and the general drilling conditions known, and also from the fact that one company in this same period spent over $600,000 in a drilling compaign in one of the districts of southern California before any oil was obtained, while another company has recently spent an equal amount in a San Joaquin field in development work before any production was secured. Other similar instances might be given, and in many cases large amounts of money have been expended without success.

In order that any company may maintain more than three or four rigs drilling at one time, a large supply of material is required and the best equipped companies have extensive shops, warehouses and yards. They are, therefore, able to take care of needed supplies and repairs at all times. One company reports a store account for drilling material of approximately $1,750,000.

California State Mining Bureau, in Bulletin No. 73, has estimated that the present total investment in the oil business represents an expenditure of at least $250,000,000.

2. Principal Operating Companies.

The principal marketing companies and their influence in the districts discussed is, in general, as follows:

The Standard Oil Company of California owns and controls land under lease in the West San Joaquin, Kern River and Whittier-Fullerton districts. In the last district this company is at the present time by far the largest producer. In each of these districts the company also purchases oil from individual producers. The entire controlled production of the Standard Oil Company is refined, and the organization is essentially planned for manufacturing and marketing the petroleum products.

The Southern Pacific Company, through its fuel bureau, formerly known as the Kern Trading and Oil Company, owns the largest amount

of land, principally in the West San Joaquin fields. This land is only partially developed and is now involved in the litigation discussed in Chapter III, which prevents further development. The K. T. & O., as it was known, buys oil from small producers and from the marketing companies, and also exchanges the light refining oil produced from its land for heavier fuel oil or refinery residuum. It is not a marketing company, however, as it supplies its entire production to the Southern Pacific Company for operation of its locomotives. The Southern Pacific Company also controls the Associated Oil Company and the subsidiary Amalgamated Oil Company, through the ownership of 51 per cent of the stock of the Associated. The Associated Oil Company operates lands and buys oil in all the districts of the state except in Ventura County. Part of this oil is refined, and the company does a general marketing business and only part of its output goes to railway use.

The Independent Oil Producers' Agency is an organization made up of over 100 small producers in the San Joaquin Valley. This agency was formed in order to get the advantage of organization in marketing their products. At the present time, the agency output is controlled through a contract with the Union Oil Company, which stipulates a fixed price to be paid for the oil as produced in the fields.

The Union Oil Company, in addition to the control of the agency just mentioned, owns large areas of land in the Whittier-Fullerton and Central Coast districts and smaller areas in the West San Joaquin and Kern River fields. This company buys oil in each of the fields where operations are conducted, and is a general refining and marketing company.

The Shell Company of California owns lands in the Coalinga, Ventura and Santa Maria fields, but at the present time its only production is obtained in Coalinga. Like the Standard, all of this oil is refined and only sold after manufacture.

The Atchison, Topeka and Santa Fe Railway Company owns land and produces oil in West San Joaquin, Kern River and Whittier-Fullerton districts, through the ownership of two oil companies, Chanslor-Canfield Midway Oil Company and Petroleum Development Company. These companies act as a fuel bureau for the Santa Fe Railway, and no oil is sold for general consumption.

In Table 8 the control of California production is given by fields.

VI. *Summary.*

To summarize the present condition of the California oil industry, as regards production, it is evident:

First—That the gross production of oil in California has been practically stationary for over a year at 8,000,000 barrels per month and is maintained at that figure only by an unprecedented activity in drilling.

Second—That under existing conditions, as to land and material available for drilling, this production can not be long maintained, owing to the cumulative effect of the decline of old wells.

Third—The oil industry is of such a nature that it can be carried on most economically and efficiently by companies with ample resources and large acreage.

TABLE

Total Production of Crude

Total Production of Crude Oil in California From the Beginning of the

[From Standard Oil

Year	Kern River	McKittrick	Midway	Sunset	Coalinga	Santa Maria-Lompoc
Prior						
1876						
1877						
1878						
1879						
1880						
1881						
1882						
1883						
1884						
1885						
1886						
1887		*				
1888						
1889						
1890					*	
1891				*		
1892						
1893						
1894						
1895						
1896					14,119	
1897					70,140	
1898		10,000			154,000	
1899	*	15,000			439,372	
1900	826,775	80,000	*	12,500	547,960	
1901	3,278,840	430,450	4,235	188,600	525,433	*
1902	8,988,046	619,296	3,048	167,558	571,233	86,888
1903	16,342,099	1,353,206	27,305	352,565	2,138,058	204,890
1904	17,226,240	1,856,225	910	390,425	5,097,853	700,450
1905	15,253,845	1,373,030	18,530	419,212	8,882,125	3,402,800
1906	12,825,166	680,756	11,800	307,550	8,401,105	4,799,411
1907	12,346,014	2,415,840	149,944	704,805	8,996,268	8,249,236
1908	13,803,579	3,076,300	434,578	1,463,510	10,725,795	8,699,350
1909	14,508,242	5,807,360	2,234,455	1,999,701	15,406,619	8,017,455
1910	14,776,435	5,471,613	11,174,207	9,218,904	18,646,470	7,607,830
1911	14,078,890	5,477,532	21,584,602	5,559,069	18,311,251	7,465,074
1912	12,446,445	5,094,465	25,948,980	5,590,824	19,546,122	6,801.966
1913	9,980,940	4,496,842	33,040,129	5,984,651	18,604,626	5,817,711
1914	7,030,545	3,820,857	37.479,228	12,546,616	15,925,887	4,303,080
1915	8,034,974	3,552,801	33,211,486	6,006,607	13,548,159	4,536.840
1916	8,402,525	3,230,644	32,156,818	6,768,658	14,381,493	4,422.410
Totals	190,149,600	48,862,217	197,580,255	57,681,754	180,934,188	75,115,391

*Indicates first well.

6.

Oil in California.

Industry to December 31, 1916, by Fields—in Barrels (42 U. S. Gallons).
Bulletin, March, 1917.]

Summerland	Newhall and Ventura County	Los Angeles and Salt Lake	Whittier-Fullerton	Lost Hills-Belridge	Miscellaneous	Total
----------	175,000	----------	----------	----------	----------	175,000
----------	12,000	----------	----------	----------	----------	12,000
----------	13,000	----------	----------	----------	----------	13,000
----------	15,227	----------	----------	----------	----------	15,227
----------	19,858	----------	----------	----------	----------	19,858
----------	40,552	----------	----------	----------	----------	40,552
----------	99,862	----------	----------	----------	----------	99,862
----------	128,636	----------	*	----------	----------	128,636
----------	142,857	----------	----------	----------	----------	142,857
----------	262,000	----------	----------	----------	----------	262,000
----------	325,000	----------	----------	----------	----------	325,000
----------	377,145	----------	----------	----------	----------	377,145
----------	678,572	----------	----------	----------	----------	678,572
----------	690,333	----------	----------	----------	----------	690,333
----------	303,220	----------	----------	----------	----------	303,220
*	307,360	----------	----------	----------	----------	307,360
----------	323,600	----------	----------	----------	----------	323,600
----------	385,049	*	----------	----------	----------	385,049
----------	470,179	----------	----------	----------	----------	470,179
1,500	524,469	257,109	----------	----------	----------	783,078
16,904	476,490	751,945	----------	----------	----------	1,245,339
39,792	298,866	905,003	----------	----------	----------	1,257,780
130,136	368,282	1,327,011	12,000	----------	4,000	1,911,569
132,217	427,000	1,462,871	60,000	----------	3,000	2,249,088
208,370	496,200	1,409,356	108,077	----------	1,500	2,677,875
183,486	443,000	1,722,887	264,397	----------	248,945	4,319,950
203,616	472,057	2,304,432	302,652	----------	----------	7,710,315
143,552	475,000	2,198,496	1,103,793	----------	----------	14,356,910
131,125	682,185	793,765	2,305,613	----------	3,670	24,334,481
120,506	650,779	1,241,304	2,224,550	----------	39,392	29,548,634
96,871	476,898	2,226,768	2,118,312	----------	29,650	34,298,041
72,810	404,379	2,675,650	2,434,512	----------	10,090	32,623,229
69,060	435,584	3,372,465	3,294,206	----------	69,090	40,102,512
67,862	498,015	5,138,959	4,273,314	----------	125,475	48,306,737
66,338	516,628	4,350,898	5,157,252	*	126,775	58,191,723
74,725	652,575	3,729,618	6,281,221	4,900	58,970	77,697,568
71,255	661,785	3,223,661	7,081,165	168,410	61,350	83,744,044
65,715	859,885	3,073,427	7,919,779	2,680,961	45,870	90,074,439
62,406	1,022,052	2,898,846	10,657,053	5,274,553	27,375	97,867,184
55,743	968,421	2,504,475	14,130,548	4,830,921	27,375	103,623,695
53,000	1,036,305	2,110,133	13,030,549	4,318,550	27,375	89,556,779
56,775	1,122,033	1,721,453	14,679,672	4,852,431	27,450	91,822,362
2,123,764	18,738,338	51,400,532	97,428,665	22,130,726	937,352	943,082,782

TABLE 7.

Production and Development of California Oil Fields at Four Month Intervals, from April, 1910, to April, 1917.

	San Joaquin Valley, West Side (Coalinga, Lost Hills, Belridge, McKittrick and Midway Sunset)		Whittier-Fullerton (Whittier, Fullerton, Coyote Hills, Brea Canyon, Puente, etc.)		Coast, Southern (Los Angeles, Salt Lake, Newhall, Ventura County and Summerland)		Coast, Central (Santa Maria, Cat Canyon and Lompoc)		Kern River	
	Monthly production	Producing wells	Monthly production	Producing wells	Monthly production	Producing wells	Monthly production	Producing wells	Monthly production	Producing wells
1910—April	3,984,000	1,084	524,000	419	366,000	1,108	580,000	147	1,119,000	1,447
August	4,310,000	1,208	547,000	428	372,000	1,138	847,000	155	1,282,000	1,582
December	3,859,000	1,378	508,000	432	354,000	1,159	632,000	169	1,245,000	1,566
1911—April	4,107,000	1,419	572,000	438	321,000	1,158	782,000	183	1,240,000	1,591
August	4,535,000	1,607	647,000	452	319,000	1,158	529,000	178	1,172,000	1,606
December	4,790,000	1,728	627,000	457	327,000	1,146	637,000	184	1,083,000	1,622
1912—April	4,629,000	1,898	620,000	463	328,000	1,172	545,000	187	1,082,000	1,600
August	5,049,000	2,061	666,000	475	336,000	1,190	586,000	188	1,051,000	1,644
December	5,084,000	2,122	754,000	428	340,000	1,205	530,000	175	994,000	1,643
1913—April	5,338,000	2,286	827,000	498	353,000	1,208	534,000	203	890,000	1,651
August	6,131,000	2,447	881,000	498	341,000	1,233	567,000	222	892,000	1,666
December	5,940,000	2,520	1,145,000	514	286,000	1,214	408,000	221	601,000	1,397
1914—April	6,296,000	2,566	1,044,000	517	----------	-------	----------	-------	592,000	1,382
August	6,703,000	2,800	1,195,000	549	----------	-------	----------	-------	624,000	1,459
December	5,479,000	2,682	1,194,000	568	279,000	1,231	344,000	235	557,000	1,385
1915—April	5,077,000	2,654	1,074,000	589	271,000	1,230	363,000	242	553,000	1,429
August	5,157,000	2,737	1,060,000	605	253,000	1,232	422,000	244	784,000	1,678
December	4,900,000	2,746	1,055,000	613	267,000	1,247	386,000	237	724,000	1,684
1916—April	4,938,000	2,891	1,173,000	627	261,000	1,246	370,000	239	723,000	1,759
August	5,423,000	3,128	1,290,000	642	234,000	1,233	394,000	235	699,000	1,838
December	5,238,000	3,302	1,368,000	637	230,423	1,232	400,000	249	697,000	1,908
1917—April	5,267,000	3,432	1,422,000	674	228,000	1,244	437,250	256	716,250	1,953

m Corporation		Shell Company of California			Miscellaneous, including Santa Fe			
Total controlled	Per cent of district	Oil from owned or leased land	Total controlled	Per cent of district	Total controlled	Per cent of district	Total produced	Per cent of state
550	10.7	540	540	10.5	275	5.3	5,130	66.2
--------	--------	--------	--------	--------	83	11.8	700	9.0
30	2.3	--------	--------	--------	65	4.9	1,330	17.2
--------	--------	--------	--------	--------	81	40.5	200	2.7
--------	--------	--------	--------	--------	56	14.7	380	4.9
580	--------	540	--------	--------	560	--------	7,740	100.0
7.4%	--------	7%	--------	--------	7.2%	--------	--------	

state production.

CHAPTER V.

STORAGE OF CALIFORNIA PETROLEUM.

I. *General Statement.*

The statistics of storage of California oil are generally known and have been widely discussed. The present investigation is largely due to the general alarm occasioned on the Pacific coast by the reported heavy drain on the oil storage to meet the increasing industrial demands, together with the fear that California might be unable to do her part in meeting the present war emergency through lack of fuel for the operation of railroads and maintenance of manufacture.

II. *Importance of Storage Stocks.*

The importance of maintaining a supply of oil in storage can not be overestimated. The marketing companies can not sell oil on samples and the industries dependent upon oil can not expand unless they have assurance of an adequate future supply, or a suitable substitute.

A reserve of oil is required for market control under normal conditions and must be maintained for safety in war times.

III. *Classification of Storage.*

The figures on storage commonly reported refer to crude oil in reservoirs and tanks in the field, in pipe lines and pine line tankage and in storage at the pipe line terminals. In addition to this, there is a certain quantity of oil in the process of manufacture at the different refineries; also refinery storage consisting of both residuum and the various refinery products. There is also a third class of storage which is in the hands of the consumers, including railroad and steamship companies.

In this report we have considered the field and pipe line storage and the refinery storage as available and have not considered oil in the process of manufacture or in the hands of consumers, as this quantity of oil must be maintained in order to continue industrial operation. For example, there is approximately 1,100,000 barrels of oil in storage along the lines of the Southern Pacific and Santa Fe railroads, but as this is only equivalent to the oil required for twenty days' operation of these railroads, it is evident that these stocks can not be further diminished without endangering the maintenance of traffic.

Unless otherwise specified, the term "storage" will be used in this report to represent crude oil stored in the field, along pipe lines and at pipe line terminals.

IV. *Relation of Storage to Production and Consumption.*

The figures of production, of consumption and of storage should be considered together. By reference to Plate XVI, it will be seen that whenever production of California oil rapidly increases, the quantity of oil in storage is also increased and a rapid increase in consumption, due to industrial expansion on the Pacific coast, tends to deplete the stock. In other words, storage statistics may be considered as a record of the pulse record of the oil industry. The waves shown in the storage curve wave plate represent, therefore, the rapid increase in production in 1903–1904 and 1909–1910 and again in 1913–1914, while the troughs follow the prosperous years of 1906 and 1916. This last decline in storage, with which we are now concerned, was accentuated by a sharp decline in production following the maximum output of 1914.

In order to bring out more clearly the relation between oil storage and the industry, Plate XVII, was plotted to show the ratio between the amount of oil in storage each month and the corresponding annual consumption.

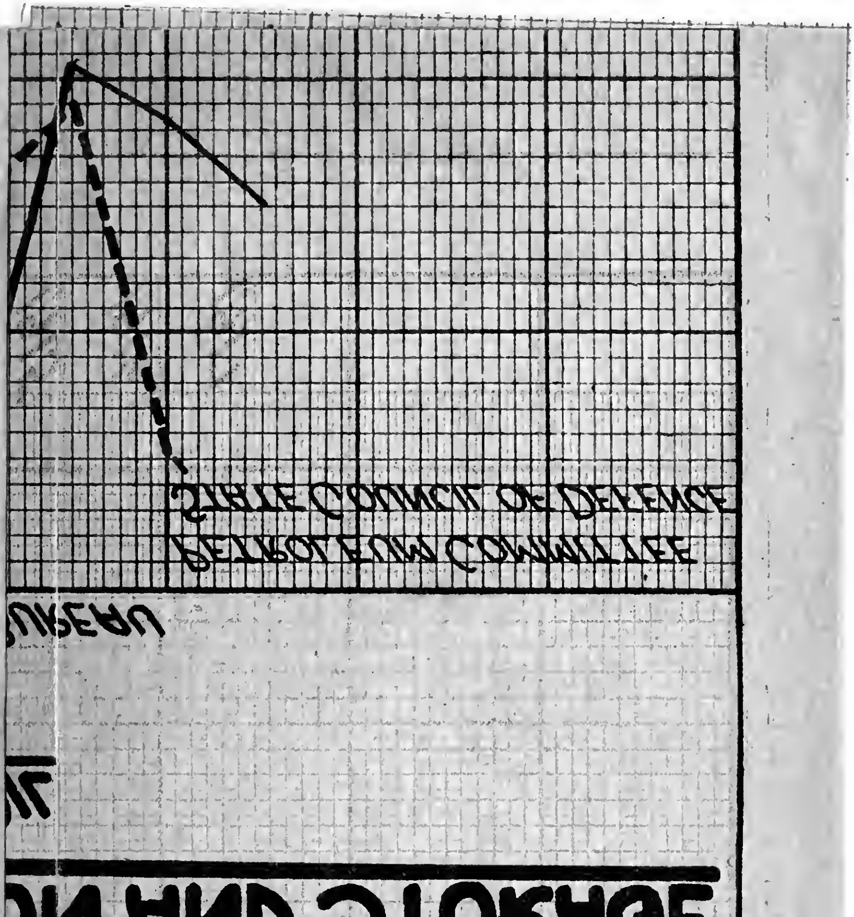
From this plate it will be seen that in August, 1906, there was oil in storage equivalent to an eight months' supply, while in September, 1908, the oil stocks were only equivalent to the consumption for a period of three and one-half months. In December, 1912, these stocks had risen until they represented a supply for six months' use and, by February, 1915, the 60,000,000 barrels in storage would have been sufficient to meet the demand for nearly eight months.

The present decline in oil storage began in September, 1915, and has since averaged over a million barrels a month, and for the six months from January 1, 1917, to July 1, 1917, has averaged approximately 1,100,000 barrels per month. The quantity in field and pipe line storage on July 1st was less than 37,000,000 barrels, or approximately four months' supply. In other words, although the actual quantity in storage had decreased 40 per cent, the increased demand has made the present supply only equivalent to one-half the storage of September, 1915.

V. *Availability of Stocks.*

Another fact to consider is the amount of the oil in storage actually available for emergency use. The best figures and estimates the committee has been able to gather show that approximately 6,000,000 barrels of the present storage would not be available.

A quantity of oil estimated at 2,000,000 barrels is required for the operation of the pipe lines of the state and about 4,000,000 barrels is in the bottoms of large tanks and reservoirs below the points of outlet.


STATE COUNCIL OF DEFENCE
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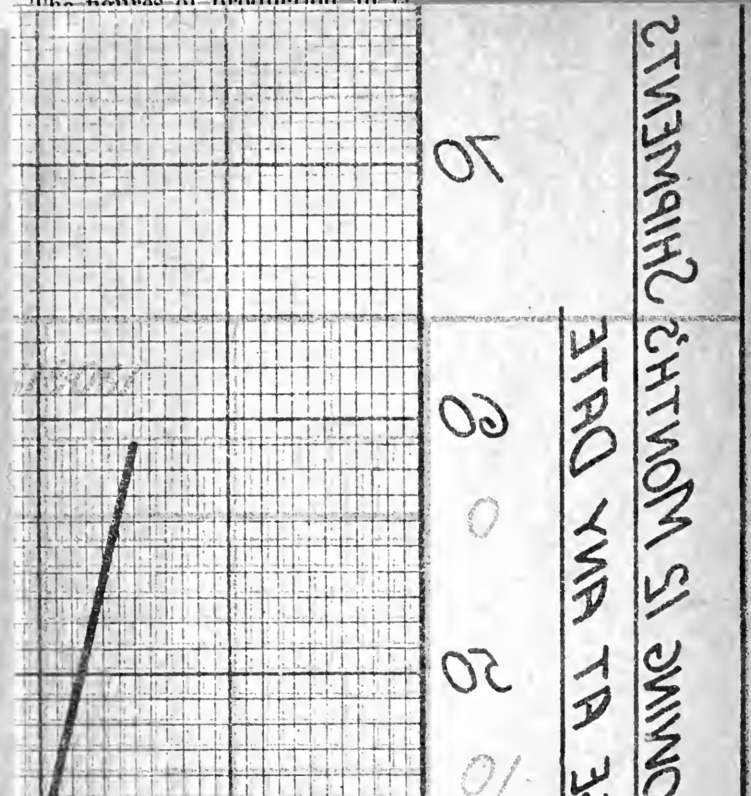
IV. *Relation of Storage to*

The figures of production of co



operation of the pipe lines or t
the bottoms of large tanks an

As a matter of fact, in some of the larger earthen reservoirs a considerable quantity of oil has undoubtedly seeped into the ground and can never be recovered economically.

On June 1, 1917, the committee estimated that 32,000,000 barrels of oil were available and each month will see this quantity rapidly decrease. The present rate of depletion would exhaust the available stock within two years and the increasing demand would tend to shorten this period.

The committee has considered that a certain quantity of crude oil is required in storage for the successful maintenance of the oil business and the industries now dependent upon oil. This safety factor we have estimated at 10,000,000 barrels of available oil, or a total of 16,000,000 barrels in field and pipe line storage. This quantity is equivalent to only a little more than thirty days' consumption. If used, as it presumably would be, to make good the difference between consumption and production, it amounts to a nine months' supply. The committee considers that under present conditions it would be very dangerous to carry on industrial operations on the Pacific coast on any smaller margin of storage oil.

VI. *Character of Oil in Storage.*

According to the figures reported by the companies having the largest quantity of oil in storage, the gravity of the bulk of this oil varies from about 14° Baume to 26° Baume, with smaller quantities of still lighter oil. In general, the light oils are refined as rapidly as possible to prevent loss of their volatile constituents. The total amount of oil in storage below 20° Baume, which has been nominally considered the dividing line between refining oil and fuel oil, was approximately 20,000,000 barrels on June 1.

VII. *Actual Quantity of Available Fuel Oil in Storage.*

If the same test of availability be applied to this heavy oil, not more than 17,000,000 barrels of the field and pipe line stocks can be counted on for use; however, at the refineries in the state, and not included in any of the above figures, 3,000,000 barrels of residuum are stored and another 7,000,000 barrels of residuum can be anticipated as one of the products from the refining of the light oil now in field storage.

The total available stocks of fuel oil can, therefore, be approximately stated as 27,000,000 barrels.

At the present rate of consumption of fuel oil, this is equivalent to less than four months' supply.

VIII. *Location of Oil in Storage.*

Plate XVIII shows the location of crude oil in storage in California on May 1, 1917. From this plate it is evident that approximately 7,000,000 barrels of oil are now stored in tank farms on San Francisco Bay. Approximately 10,500,000 barrels of oil are in tanks in the West San Joaquin fields and nearly 11,000,000 barrels are in storage in the Kern River field.

On the coast, near Port San Luis, a little less than 6,000,000 barrels are in storage, with another 1,000,000 barrels in tanks in the Santa Maria field.

In the Southern Coast and the Whittier-Fullerton fields, less than 4,000,000 barrels of crude oil are in storage. However, the greater part of the residuum in refinery storage is in this southern district.

As shown in Chapter VI, the oil in storage in southern California and in the Central Coast district is not as readily available as the oil on San Francisco Bay or in the San Joaquin Valley, owing to the lack of transportation facilities.

IX. *Construction, Cost and Capacity of Storage.*

The storage usually employed in California is of five different types:

First—Covered steel tanks;
Second—Covered reenforced concrete tanks;
Third—Covered concrete lined reservoirs;
Fourth—Covered clay reservoirs; and
Fifth—Open earth reservoirs or sumps.

The steel tanks in common use for the storage of oil in large volumes usually have a capacity of 55,000 barrels, although some storage tanks of smaller size, with a capacity of approximately 37,000 barrels, are used. These tanks are used along the pipe lines at the pumping stations.

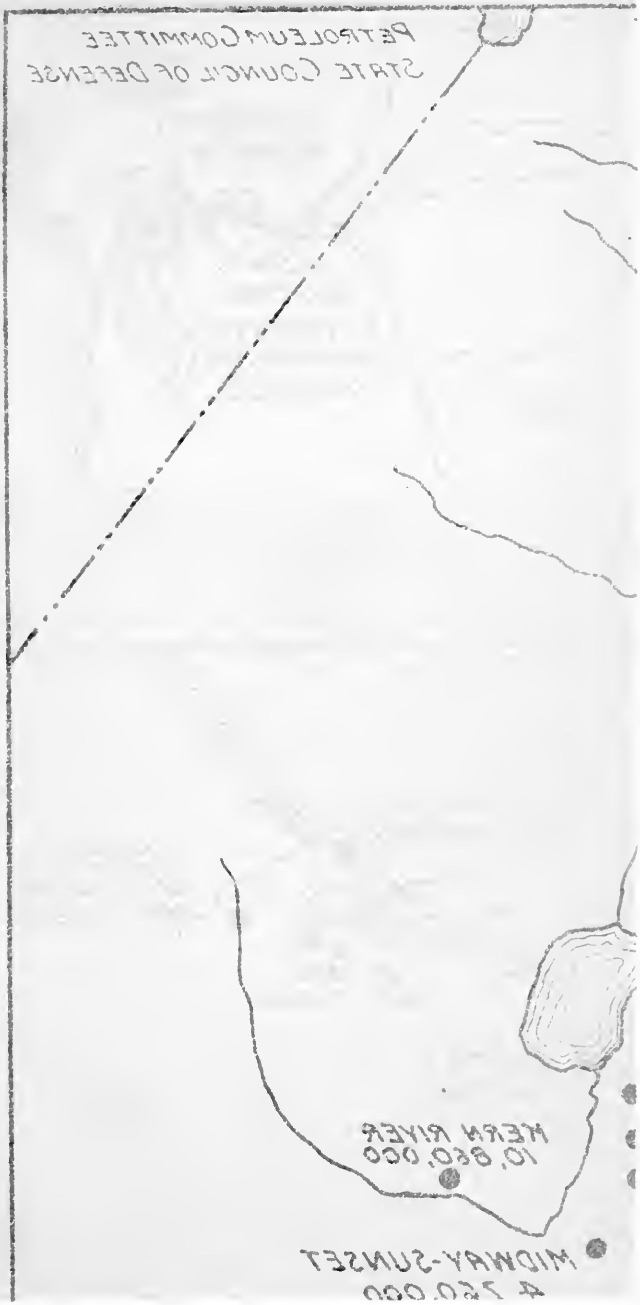
Based on the cost of materials in 1914, the cost of steel storage tanks is approximately as follows:

37,000-barrel capacity	$10,000 00
55,000-barrel capacity	13,000 00

This is equal to 24 to 27 cents per barrel of capacity.

The reenforced concrete tanks have been built in all sizes up to 1,000,000-barrel capacity. These large sizes have not proved economical or successful, while the concrete lined reservoirs with wooden roof, or with concrete roof, have been very successful.

The capacity of these reservoirs varies between 500,000 and 750,000 barrels. The various types of the concrete tanks are used at the gathering stations and at the terminal stations of the pipe lines.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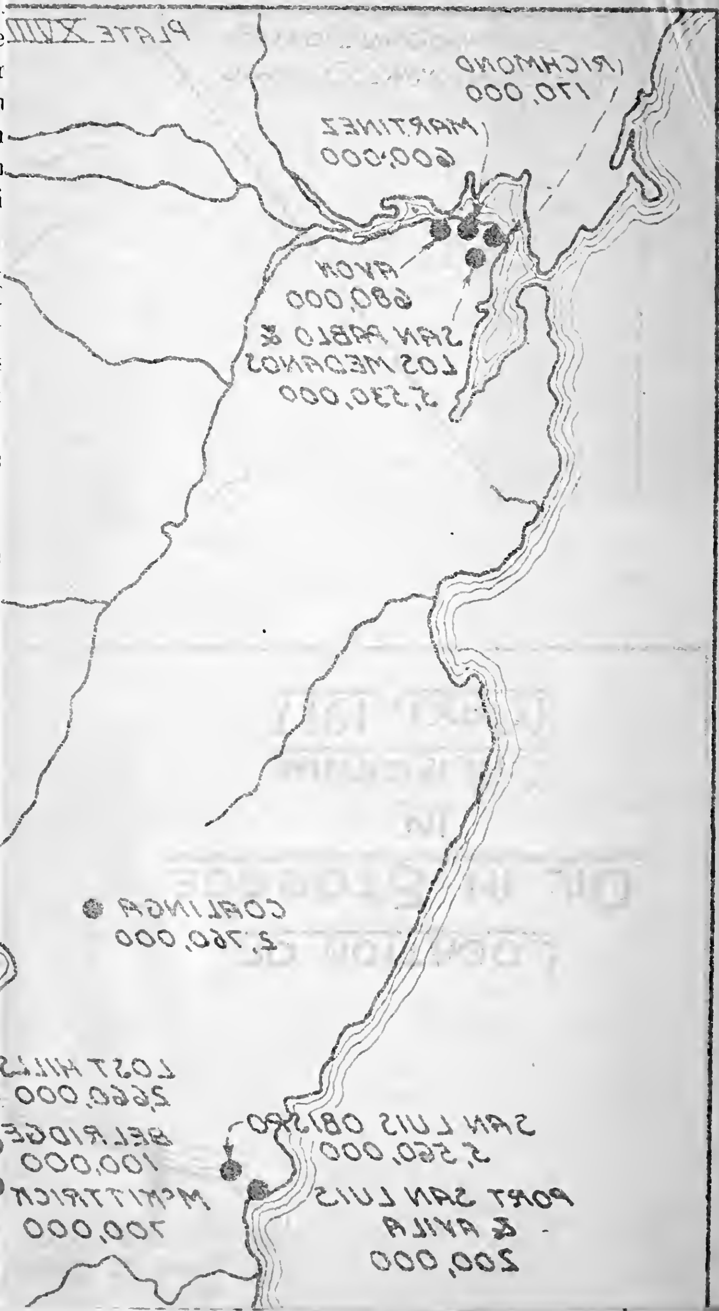

One of the large companies has a great part of its storage of heavy oil in covered clay reservoirs with capacity between 500,000 and 750,000 barrels. These reservoirs are unlined, but are covered with a wooden roof. Their cost is about 8 cents per barrel of capacity.

The open sumps are used mostly for emergency storage in the case of a sudden gusher, or for the settling of sand from the oil. Undoubtedly there has been a great deal of loss due to seepage and the evaporation of oil from these open sumps.

The losses due to leakage and evaporation in steel or concrete tanks has been estimated at less than one-half of 1 per cent per year. The loss in the unlined earthen reservoirs may vary from 2 to 5 per cent per year, depending upon the class of material used in the construction of the embankment. The higher figure as to loss occurs in cases where suitable impervious clay has not been used in lining the reservoir.

X. *Ownership of Storage.*

The ownership of field storage, and of the oil in storage, is shown in Table 9. From this table it is evident that the Standard and Union Oil companies together own approximately 85 per cent of the oil in storage in California at the present time.

TABLE 9.

Storage Facilities and Stocks of Crude Oil in California, May 1, 1917.
(Barrels.)

	San Joaquin Valley District		Coast and Southern District	
	Storage facilities	Oil in storage	Storage facilities	Oil in storage
Associated Oil Co.	11,040,000	1,790,000	780,000	260,000
General Petroleum Co.	*900,000	760,000	*1,100,000	920,000
K. T. & O. Co.	4,130,000	550,000	----------	----------
Shell Co. of California	2,290,000	1,430,000	----------	----------
Standard Oil Co.	39,200,000	19,510,000	3,160,000	2,170.000
Union-Agency	5,010,000	4,590,000	10,100,000	6,360,000
Miscellaneous	----------	200,000	----------	340,000
Totals	62,570,000	28,830,000	15,140,000 62,570,000	10,050,000 28,830,000
Grand totals	----------	----------	77,710,000	38,880,000

*Estimated.

Terminal	Description
:ation ---------	Branch line to Trunk Line No. 4.
----------------	Trunk Line No. 1 to coast.
osta -----------	Trunk Line No. 2 to San Francisco Bay.
lro ------------	Trunk Line No. 3 to San Pedro.
Station ------	Branch line connecting with Midway branch.
----------------	Trunk Line No. 1.
osta -----------	Trunk Line No. 2.
tation ---------	Branch line to Trunk Line No. 4.
os --------------	Branch line to Trunk Line No. 2.
	Branch line to Trunk Line No. 3.
n --------------	Branch line to Trunk Line No. 1.
nd Refinery ---	Trunk Line No. 4.
ick ------------	Branch line to Trunk line No. 1.
osta -----------	Trunk Line No. 5 to San Francisco Bay.
a --------------	Branch line to Trunk Line No. 4.
n --------------	Branch line to Trunk Line No. 1.
osta -----------	Trunk Line No. 2.
ey -------------	Trunk Line No. 6.
z --------------	Trunk Line No. 7.
n Luis.	
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Station ------	Connecting with Whittier-Fullerton Line.
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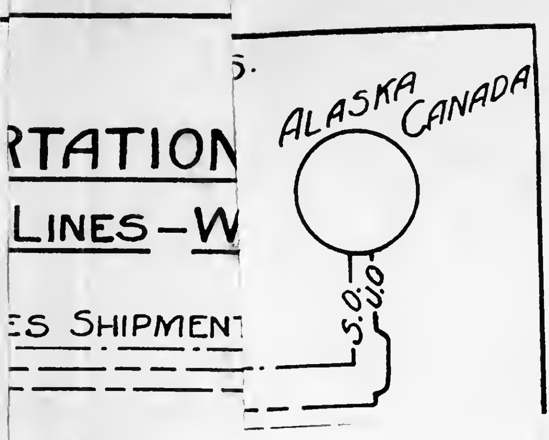
*	* * * * *
----------------	From Trunk Line No. 3 (distribution).
gton -----------	General Petroleum Refinery (distribution).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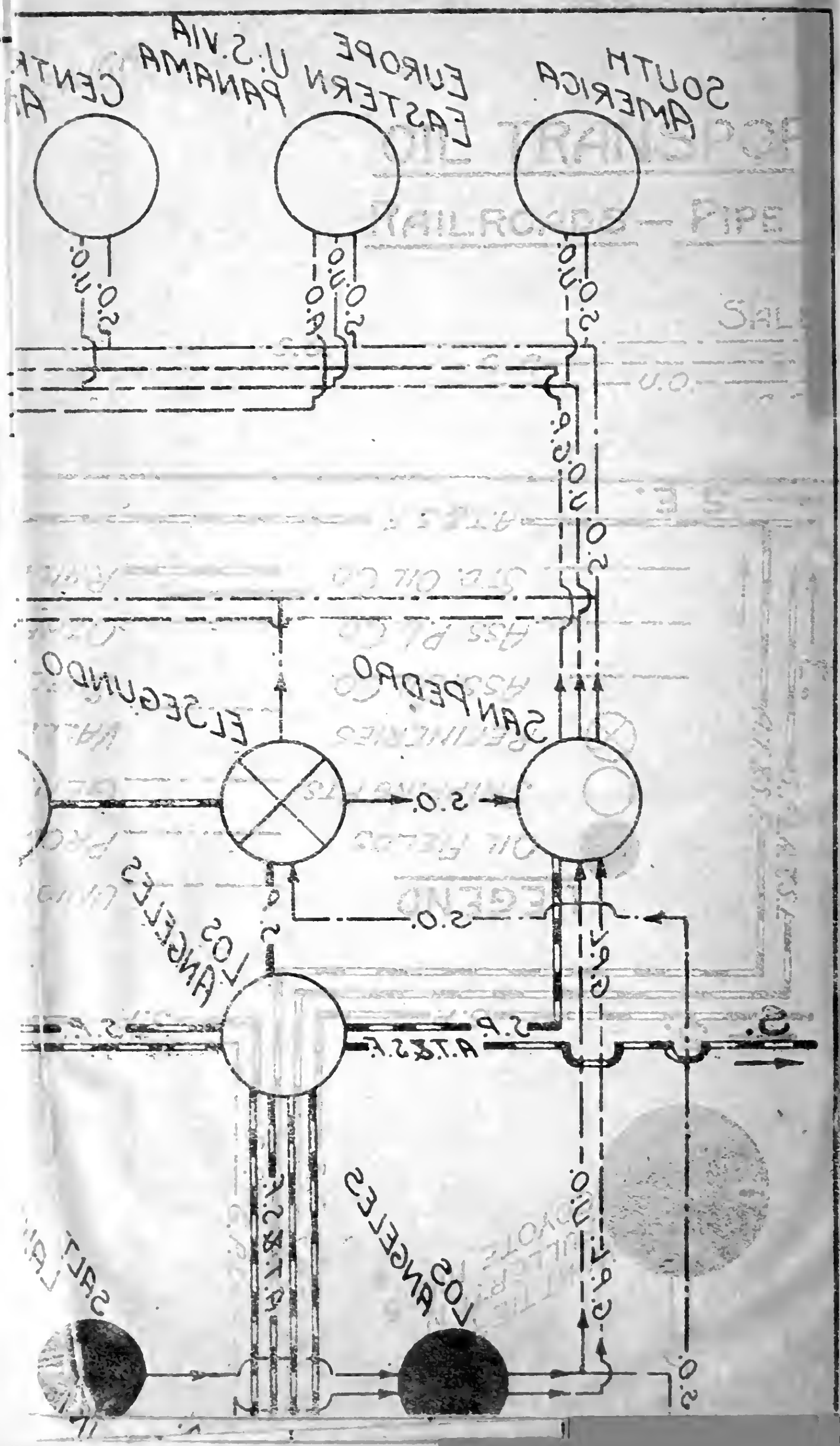

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EL SEGUNDO
LOS ANGELES
LOS ANGELES
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S.O.

CHAPTER VI.

TRANSPORTATION OF CALIFORNIA PETROLEUM.

I. *Importance of Transportation.*

1. Value Dependent on Availability.

The transportation of oil has always been a controlling factor in the industry. This applies to both the transportation of crude oil from the wells to the refineries and the distributing points; and also the distribution of the refined products and residuum from the refineries and the distribution of crude oil sold directly. The value of oil, or any product thereof, depends on its availability.

As pointed out in Chapter II, the Allies are not able, at the present time, to take full advantage of their control of the oil fields of the world. The present difficulty of ocean transportation makes this an extreme case, but it illustrates the necessity of an adequate method of delivering oil to the point of use. As another example, the impending shortage of oil in the United States could easily be met if facilities were available for bringing larger quantities of Mexican oil to this country.

The reports of the Federal Trade Commission on pipe line transportation (1914) and on the price of gasoline (1916) show that the control of the development and production of the oil fields of this country rest largely with the pipe line companies.

2. Necessity of Pipe Lines in California.

The development of the oil industry in California shows a similar history, since the control and disposition of the oil produced has been almost entirely with the marketing companies owning pipe lines from the fields. At the present time, all the important fields in California and practically all the wells are connected with pipe line systems. However, it is unfortunately true that the most productive fields are relatively inaccessible and that rather long lines of pipe are required to bring the oil to tidewater for refining and shipment.

The facilities for transporting the oil from the various fields of the state, together with the ownership of these lines, are shown in Table 10 and in Plates VI and XIX. In the latter the approximate route followed by the pipe lines from the field to the point of delivery is shown, while in Table 11 the transfer of oil from one company to another and the destination of the oil from each field are indicated. The location of pipe lines is naturally controlled by the position of the terminals and the topography of the intervening region.

II. *Control of Pipe Lines.*

The companies controlling pipe lines in the state of California are as follows:

Standard Oil Company of California, which operates two 8-inch lines, with 12-inch loop from Bakersfield to San Francisco Bay, with connecting branches from Midway, Lost Hills and Coalinga. This company also operates two pipe lines from the Whittier-Fullerton district to the El Segundo refinery; one from El Segundo to San Pedro Harbor, and small pipe lines from the Southern Coast fields to Ventura.

In the Central Coast district, the Standard Oil Company owns one line to Port San Luis, which is idle at the present time.

The Union Oil Company owns lines from the Whittier-Fullerton and Southern Coast fields to Los Angeles and San Pedro; from the Central Coast to Port San Luis and, through the ownership of stock of the Producers Transportation Company, controls pipe lines from the San Joaquin fields to Port San Luis and has recently acquired, through the purchase of the Pinal Dome Oil Company, two small lines from the Santa Maria field.

The Associated Pipe Line Company is owned jointly by the Associated Oil Company and the Southern Pacific Railroad Company. This company operates 8-inch pipe lines from the San Joaquin Valley fields to Port Costa, on San Francisco Bay and the Associated Oil Company also owns a 6-inch pipe line from Coalinga to Monterey Bay; an 8-inch line from the Central Coast fields to the refinery at Gaviota, and one from the Southern Coast district to Los Angeles.

The General Pipe Line Company, which is a subsidiary of the General Petroleum Corporation, owns and operates the only pipe line which transports oil from the West San Joaquin fields south to Los Angeles and San Pedro. This company also owns a branch line, which delivers oil to Mojave on the Santa Fe Railway.

The Valley Pipe Line Company, which is a subsidiary of the Shell Company of California, owns and operates a combination 8-inch and 10-inch line from the Coalinga district to their Martinez refinery.

III. *Pipe Lines From California Fields.*

By reference to the plates it may be seen that the oil produced in the San Joaquin Valley may be delivered north to San Francisco Bay through any one of three different systems; west, to tidewater; through either of two lines, one delivering to Monterey and one to Port San Luis; or south, to Los Angeles and San Pedro through one pipe line. From the Whittier-Fullerton field there are two systems of pipe lines to Los Angeles and to tidewater, and the problem of transportation from this important district is not the question of movement from the fields, but

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of delivery to the point of use. Nearly all of the small fields in the Southern Coast district are served by both pipe line and railroad. The Central Coast district has three short lines for the delivery of oil to tidewater at either Gaviota (Alcatraz) or at Port San Luis. There are, however, no pipe line facilities for the delivery of oil to San Francisco Bay from any district outside the San Joaquin Valley, and all of the Southern and Coast districts are therefore dependent upon steamer transportation to carry oil to the principal marketing centers.

This fact is of great importance in the present emergency, since additional oil developed and produced in the Whittier-Fullerton field can not readily be used to relieve the shortage in northern California or the Puget Sound district; for this reason, the San Joaquin fields, which are the most distant from marketing centers, are called upon to meet the greater part of the increased demand.

IV. *Details of Pipe Lines.*

In order to get a view of the amount of capital required for the successful operation of the oil business, the following details of pipe lines are supplied:

1. Line.

The diameter of the main pipe lines as shown in Table 10 varies from six to twelve inches. The 8-inch pipe, weighing 28 pounds per foot, is chiefly used in California for trunk lines, ten and twelve-inch pipe sometimes being used either singly or in multiple in order to reduce the friction and overcome the increased resistance due to elevation or longer distances between stations, all with the object of maintaining as nearly as may be a uniform working pressure at the various stations throughout the system. The cubic capacity of an 8-inch line is about 328 barrels per mile.

2. Pumping Stations.

The pumping stations, usually from fourteen to twenty-five miles apart, are so located as to insure, as nearly as practical, a uniform and economic pumping pressure throughout the system, and if possible are situated near good water supply.

These pumping stations consist of storage tanks, oil heaters, boilers, pumps, and the necessary buildings for equipment and crew. The storage tanks in common use in California for storing oil at pumping stations are made of steel with a capacity of 37,500 or 55,000 barrels. At the initial or gathering stations and at the terminals of the system covered reinforced concrete reservoirs are often used. These are built with a capacity varying between 500,000 and 1,000,000 barrels.

Pump stations frequently have as much as 1,000 boiler horsepower for the operation of either direct-acting duplex pumps or pumping engines with crank and fly wheels. The design of the pumps must be

such as to qualify them with a steam pressure of 135 pounds per square inch for effective service against pumping resistance of 600 or more pounds per square inch.

3. Cost of Pipe Lines.

The cost of pipe lines in California is much higher than similar lines constructed in the eastern oil fields:

First—Because the oil pumped is heavier and a greater number of pumping stations are required;

Second—On account of the freight charges on steel pipe and other materials.

In California, the cost of an 8-inch pipe line complete, with stations, on the basis of the cost of materials in 1914, was in the neighborhood of $20,000 per mile, the cost of the 8-inch pipe in the ground being about 35 or 40 per cent of the total. At the present time, the price of the pipe is more than double that of 1914 and the cost of material and labor has also increased.

Reference to Table 10 shows that there is a little over 2,000 miles of main trunk pipe line in the state of California.

V. *Operation of Pipe Lines.*

1. Statement of Problem.

A factor of great importance in the transportation of California oil is its physical character as regards gravity and viscosity, since the principal resistance to pipe line transportation is the viscosity of the oil. The chief measure employed to reduce or control the influence of this factor is the heating of the oil. In the Eastern oil fields, where oil is relatively light, it is pumped generally at atmospheric temperature, while in California, where a great part of the oil is below 18° Baume 0.9459 sp. gr., it is heated to a temperature between 125° and 170° F. at each pumping station. Higher temperatures cause gasification which makes pumping difficult. At a low temperature the viscosity decreases at first rapidly with rise of temperature and then more and more slowly. The heavier and more viscous grades have to be heated to higher temperatures than the lighter ones, and a point is reached when the pumping of the oil (somewhat below 15° Baume 0.9655 sp. gr.) in this manner is very expensive.

2. Operation of Pipe Lines.

In California practice, the oil from the well is usually discharged with a considerable amount of sand and often with a large amount of water. In order to get as clean oil as possible, the well delivery is made into a separating tank, from which the oil is pumped into the producer's shipping tank, where it is measured by the pipe line company and then allowed to flow by gravity, or, if necessary, pumped to the storage tank

at the pipe line gathering station. The oil is then pumped to the receiving tank of the nearest main line pumping station, and thence through the pipe line system to the terminal.

3. Method of Operation of Hot-Oil Lines.

For the purpose of transportation, the California pipe line companies classify the oil into fuel oil and light refining oil. The dividing point of these two grades is placed by the Standard Oil Company at 18° Baume (0.9459 sp. gr.) and by the Associated Oil Company at 22° Baume (0.9210 sp. gr.). The oil is stored separately according to gravities and the minimum runs of one grade are kept as high as possible and seldom fall below 100,000 barrels.

As examples of the difficulty of transportation of heavy oil, many of the companies run the low gravity oil below 18° Baume (0.9459 sp. gr.) as infrequently as possible and in as large a run as can be obtained, never less than 100,000 barrels, usually between 250,000 and 500,000 upward to several million barrels. Oil under 15° Baume (0.9655 sp. gr.) can not be readily pumped through small pipes on account of the rapid cooling of the line. The oil produced in the Casmalia field in the Central Coast district must be mixed with light oil, or heated by auxiliary steam pipe, or even specially treated by cracking, before shipment through the pipe lines.

In order to operate to its highest efficiency, one of the companies operates its "hot-line" to transport oil under 22° Baume (0.9210 sp. gr.) for twenty days, and oil lighter than this for the remaining ten days of every month. The light oil is run preferably during cold or wet weather, the heavier product being pumped during the summer months. It is claimed that during the first winter of the operation of the Producers Transportation pipe line its daily capacity was reduced from about 25,000 to about 3,600 barrels per day because the line had to be operated continuously with heavy oil. One of the pipe lines from Salt Lake field to Los Angeles has pumped as high as 18,000 barrels of light oil per day in hot weather, but on cold days the average of fuel oil has fallen as low as 800 barrels.

The different qualities of oil are pumped successively, and although a certain amount of mixture of oils of different gravities takes place, particularly at the pumping stations, the main bulk of the run retains its identity. At the terminal of the pipe line a careful check is kept on the rate of pumping and amount delivered so that the end of a run is known ahead of time and the flow of oil of different gravity is diverted to another tank.

4. Working Capacity of Pipe Lines.

The capacity of pipe lines of given diameter varies with the working pressure, the viscosity of oil (which in turn varies with its composition and temperature), climatic conditions (temperature, rainfall), distance

between stations, available storage capacity, and the topography of the region traversed by the line. Roughly speaking, the capacity of pipe lines increases with the size in about the ratio of the square root of the fifth power of the diameter. The capacity increases faster than the square of the diameter as the friction decreases with the increase in size. This, however, is somewhat offset by the fact that with smaller pipes a higher working pressure can be used. Thus, the capacity of a 6-inch line, operating with 800 to 900 pounds pressure, is between 12,000 and 17,000 barrels a day, and that of an 8-inch, working under a pressure of 700 to 750 pounds, from 20,000 to 25,000 barrels. The average spacing of the stations in each case will be about 14 miles. In California an 8-inch hot-line with adequate pumping equipment will handle between 20,000 and 30,000 barrels of 16° Baume oil per day.

5. Present Situation in Pipe Line Transportation.

The estimated capacity of the pipe lines serving the different districts of the state for the average gravity of oil transported is shown in Table 12, which also shows the average quantity shipped through these lines for the first four months of 1917.

From this table, it will appear that there are adequate pipe line facilities for transporting oil from the fields and for taking care of an increase in production.

TABLE 12.

Pipe Line Transportation of California Oil.

(All figures in terms of thousands of barrels per month.)

District	Point of delivery	Capacity of all lines	Average shipments
San Joaquin	San Francisco Bay	4,500	4,000
	Monterey	450	200
	Port San Luis	1,500	1,100
	Vernon, Mojave	800	740
Whittier-Fullerton	Los Angeles, San Pedro	1,350	1,230
Southern Coast	Los Angeles, San Pedro	300	100
Central Coast	San Luis, Gaviota	1,650	360

6. Tank Car Shipments.

In Table 11 the operations of the pipe lines of the state are indicated for the single month. The figures in this table are averaged from the first four months of 1917, but represent fairly well the actual working conditions at any given date in this period. By reference to this table it will be seen that a little more than 10 per cent of the total shipments from the fields are handled by tank cars. These tank car shipments represent, in large part, very heavy oil below 15° Baume and, in part, is lighter oil.

Some of these tank cars deliver their oil along the railroad lines for locomotive use, while some of them are sent direct to the mines and smelters of Arizona and Nevada.

VI. *Possible Coordination of Industry.*

At the present time there is a great shortage of tank cars and tank steamers and it appears to the committee that a considerable saving could be made by the complete coordination of the oil industry in the matter of transportation. To some extent the marketing companies are now cooperating in order to facilitate delivery and to arrange for exchange of oil. This is shown in Table 11.

For example, the Southern Pacific Company trades its light oil, suitable for easy refining, for heavy oil below 21° Baume, and other companies transfer a part of their oil, using various bases of exchange. To a large extent, the General Pipe Line Company acts as a transportation agent for the southern divisions of the Santa Fe and Southern Pacific railroads. However, this cooperation is not as complete as it might be.

Oil travels in opposite directions in parellel pipe lines and much of the oil from the San Joaquin fields takes a roundabout route to reach San Francisco Bay.

Oil is shipped through a pipe line south from the West San Joaquin fields to Los Angeles, and oil produced in Southern California is shipped from San Pedro north by vessel.

Oil for Arizona may go from Casmalia, McKittrick or Coalinga field when there is relatively a surplus of oil in southern California, whence oil could be shipped with a shorter haul to partially relieve the shortage of tank cars.

Oil is shipped by steamer from San Pedro to Puget Sound and from San Francisco to South America, so that steamer routes cross each other.

In the matter of tank cars, it is worthy of note that one of the marketing companies reports that they are behind in their orders for delivery of fuel oil to the extent of 5,000 cars, although they have ample loading facilities at their refineries.

One of the reasons for the long distance shipments made in tank cars lies in the fact that under the existing freight tariffs the rate charged on oil shipments to terminals outside of the state is the same from all terminal points in the state. From a monetary standpoint there may be no advantage, therefore, in shipping from the nearest field to the point of delivery, but an economy in the use of tank cars could be effected by such a practice.

VII. *Distribution of Oil.*

In general, the conditions in regard to distribution of oil to the point of use are unsatisfactory. This problem is much more complicated than the transportation of oil from the field and greatly increased tank car and tank steamer facilities are required to handle California oil and its products over the area now dependent upon this state for its oil supply.

Table 13 shows the number of tank cars now used in the distribution of California oil, and the number and total capacity of the tank steamers now operating on the Pacific coast. In Plate XIX these steamer routes are indicated.

The capacity of the tank cars varies from 200 to about 300 barrels, and the average daily movement of these cars is probably not more than 50 miles per day. The Southern Pacific Railroad reports a movement of 75 miles per day in handling their own oil for their own use, but this traffic is organized and expedited in every way.

TABLE 13.

Tank Cars and Steamships Owned (or Chartered) by Railroad and Oil Companies of California.

Company	Tank cars		Steamships	
	Number	Capacity, barrels	Number	Capacity, barrels
General Petroleum Company	28	6,264	3	487
Associated Oil Company	342	89,880	5	230,655
Shell Company of California	53	14,980	3	145,500
Standard Oil Company	925	260,000	17	518,033
Union-Agency	132	28,579	15	883,352
Totals—oil companies	1,480	*399,703	43	1,778,027
Northwestern Pacific	----	----		
Salt Lake	211	61,000		
Atchison, Topeka and Santa Fe	800	190,500		
Southern Pacific	2,572	612,000		
Western Pacific	169	40,300		
Totals—railroads	3,752	903,800		
Grand totals	5,232	*1,303,503	43	1,778,027

*Estimated.

On the basis of this movement, and the number of cars now in use (5,232), it will be seen at once that a greatly increased number would be required to afford any material relief to the car shortage. In this connection it must also be borne in mind that the present shortage of steel makes the construction of any large number of tank cars very difficult, and also that increased tank car shipments would require an

increased number of locomotives, and would result in increased consumption of oil. At this time for reasons brought out in Chapter VIII, it is important not to increase the amount of railroad traffic, but to reduce it in every possible way.

The tank steamers have a capacity ranging from 10,000 to 65,000 barrels per month and have an average monthly mileage of from 5,000 to 6,000 miles.

Some additional steamers are under construction at the present time, but the United States Government and the British Government have already taken several tankers from the Pacific coast, and the National Council of Defense has asked the California oil companies to release every possible steamer for Atlantic service. No material relief can, therefore, be anticipated from this new construction during the period of the war.

VIII. *Summary.*

The principal facts in regard to the transportation of the California oil to which the committee would direct attention are:

First—That pipe lines are necessary for the transportation of California oil and that the control of a large quantity of oil is required before the expense of the installation of a pipe line is justified.

Second—That the present pipe lines of the state have ample capacity to transport oil now produced in the field and to care for a material increase in this production.

Third—That transportation facilities for the delivery of oil produced in southern California to northern markets are at present inadequate.

Fourth—That there is a great shortage in tank cars and tank steamers which greatly hampers the delivery of California oil and its products to the point of use, and no material relief can be anticipated from new construction during the period of the war.

Fifth—That some saving could be made by complete coordination of the oil industry as regards transportation.

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CHAPTER VII.

REFINING OF CALIFORNIA OIL.

I. *Scope of Investigation.*

It is not within the scope of the present investigation to attempt a complete report on the refining of California petroleum. The subject of refining is too complex to be adequately discussed without a special study, and would then require a full treatise for comprehensive treatment.

The recent publications which cover, in part, the refining of California petroleum are:

American Petroleum Industry, Bacon and Hamor, 1916.
Bureau of Mines Bulletin, 114.
Manufacture of Gasoline and Benzene-Toluene from Petroleum and Other Hydrocarbons, W. F. Rittman, C. B. Dutton and E. W. Dean, 1916.

In order to cover the present status of the oil industry in California, the committee investigated the present capacity of the California refineries, together with their present output, and their plans for future development.

II. *Composition and Character of California Oil.*

Crude petroleum is a mixture of hydrocarbons in variable proportions with small quantities of oxygen, nitrogen and sulphur present as impurities. California oil is also mixed with small quantities of water and base sediment. In the Eastern oil fields of the United States, the oil has a paraffin base, and usually contains 66 per cent, or more, of hydrocarbons of methane (marsh gas) series. In California nearly all the oil is asphaltic, sometimes containing more than 50 per cent of hydrocarbons belonging to the naphthene series, and also contain large proportions of the hydrocarbons usually found in coal tar, known as the aromatic of benzole series.

III. *Basis of Refining Methods and Classification of Products.*

1. Properties of California Oil.

The average properties of oils from the different California fields are shown in Table 18. The separation of the hydrocarbons in crude oil may be accomplished by distillation, since these hydrocarbons have varying boiling points.

Bulletin 114 of the United States Bureau of Mines, referred to above states:

> "Each of the hydrocarbons of high boiling point contained in such mixtures is, during the process of distillation, exposed to various degrees of temperature below its own boiling point, so long as the hydrocarbons of lighter gravity and boiling point are not removed from the still. Consequently, the liquid hydrocarbons of high boiling point may remain exposed in the still to temperatures below their boiling point for a number of hours."

2. Basis of Separation.

While separation of oils into their constituent hydrocarbons is, therefore, possible, it is never carried out in actual manufacturing, and the oil is separated merely into such portions as will best fill the requirements of trade. These requirements are largely dependent upon the boiling point, or volatility of the products, so that separation by distillation supplies a double purpose.

The lighter products, which are easily vaporized, and which form, with air, an explosive mixture, are used for internal combustion engines.

The next group is more difficult to vaporize, is distilled at a higher temperature, and, therefore, forms an illuminating oil which may be safely burned in lamps.

Another class, which may be vaporized with still greater difficulty, forms suitable lubricants. It is evident, from the above outline, that each one of these classes is better by being separated from the others.

3. Classification of Refineries.

The principal refineries of California now in operation are shown in Table 14. They represent a total investment of approximately $20,000,000.00. These refineries may be roughly considered under three heads: First, refineries which carry the treatment of a part of the crude oil to complete distillation, and, as a result of this fractionation, obtain a full series of refined products. Second, the so-called topping plants treat the lighter grades of crude oil with the object of obtaining gasoline and a high grade of distillate, and, incidentally, a large quantity of fuel oil. Third, plants, which treat the heavier grades of crude oil, in order to produce road oil and asphalt.

In addition to these three classes of oil refineries, there are also casinghead gasoline plants, which recover high-gravity gasoline suitable for blending with distillate. These are listed in Table 17, and will be separately considered.

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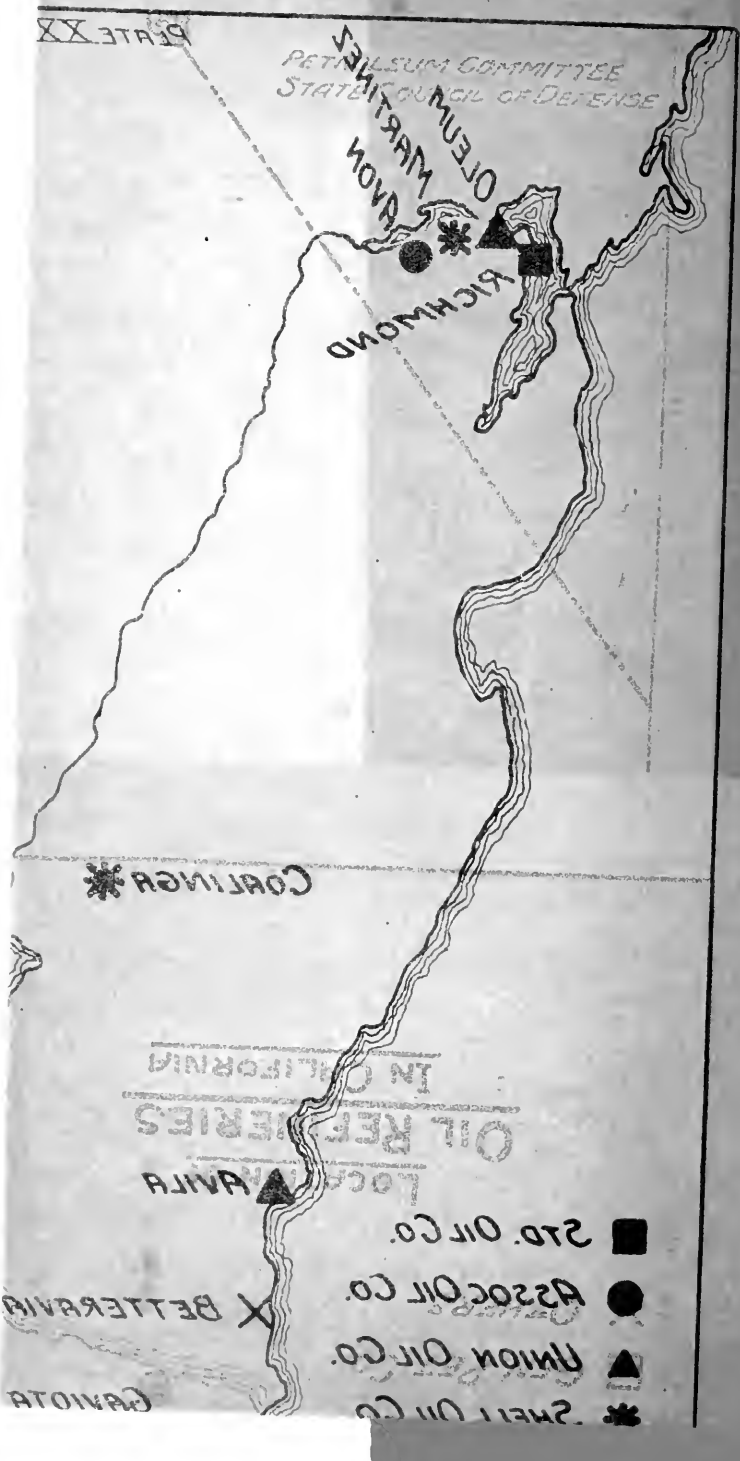


PLATE XX
STATE COUNCIL OF DEFENSE
OLEUM
MARTINEZ
AVON
RICHMOND
COALINGA
AVILA
BETTERAVIA
GAVIOTA
IN CALIFORNIA
STD. OIL CO.
ASSOC. OIL CO.
UNION OIL CO.

4. Principal Products of California Refineries.

The products manufactured from California petroleum by the first class of refineries, may be grouped as follows:

- Gasoline, now averaging about 57° Baume.
- No. 1 Tops, which include gasoline stock, and may be anywhere from 50° to 56° Baume.
- Engine distillate, with a gravity of from 44° to 50°.
- The distillates lighter than 44° Baume are sometimes known in the industry as water-white distillate.
- Kerosene stock, which is amber in color, and has a gravity of from 40° to 42° Baume and requires further refining before marketable kerosene can be produced.
- Gas oil, dark in color, 34° to 40° Baume.
- Stove distillate, which is also dark in color, and of 30° to 36° Baume.
- Diesel fuel oil, usually 26° to 30° Baume.
- Fuel oil, or residuum, usually of a gravity of 15° to 20° Baume.

In addition to these, lubricant stocks may be produced of all gravities from the light spindle oils, gravity 24° Baume, down to the heavier engine oils, to cylinder oil, gravity 15° Baume.

IV. *Development of Refining Process.*

In the first development of refining of California oil, it was found that the comparatively large proportion of carbon to hydrogen present in the benzole series produced a refined oil which burned with a smoky flame in the lamps manufactured for burning Eastern oils. For this reason, and on account of the low gravity of the oil produced from the first fields discovered in California, California oils came to be used as a series of heating and power, rather than as a series of lighting. Later, it was found that the aromatic hydrocarbons could be removed from the lamp oil if these were distillates refined with fuming sulphuric acid.

The gasoline produced in the manufacture of kerosene was at first considered as a by-product. With the rapid increase in the use of automobiles, however, gasoline has come to be the most important refined product, and the increased capacity of the refineries to meet the demand for gasoline has resulted in an increased amount of other distillates, including kerosene, and one of the problems of the refining and marketing companies has been to develop suitable markets for this increased quantity of illuminating oil.

At the present time, the demand for lubricating oil is not great enough to warrant the manufacture of the maximum quantity possible, and the greater proportion of what, in the complete fractionation, would be lubricating stock, is now thrown into fuel oil and is burned under boilers.

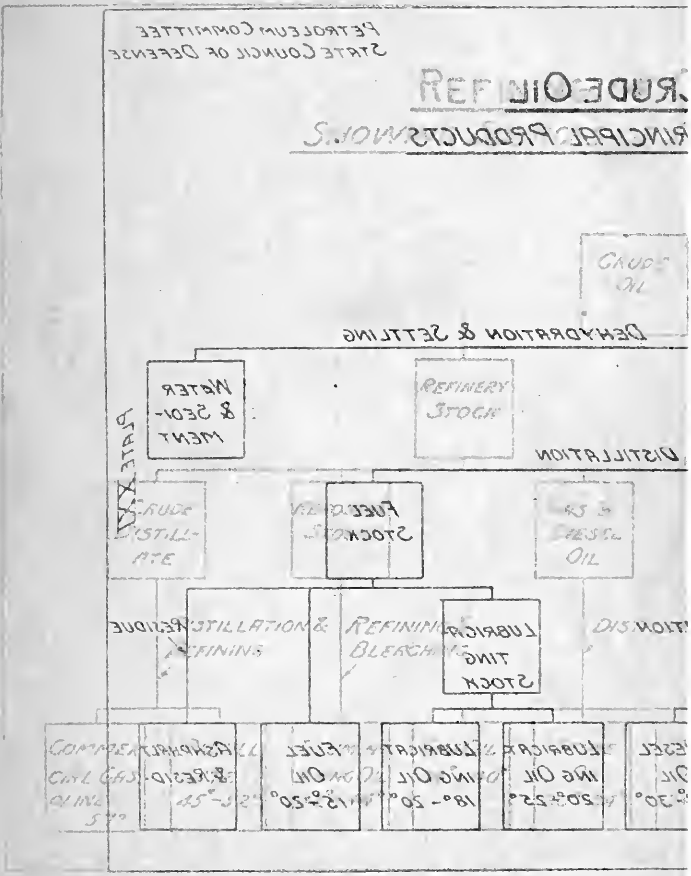
TABLE 15.

Input of Crude Oil to Principal California Refineries.

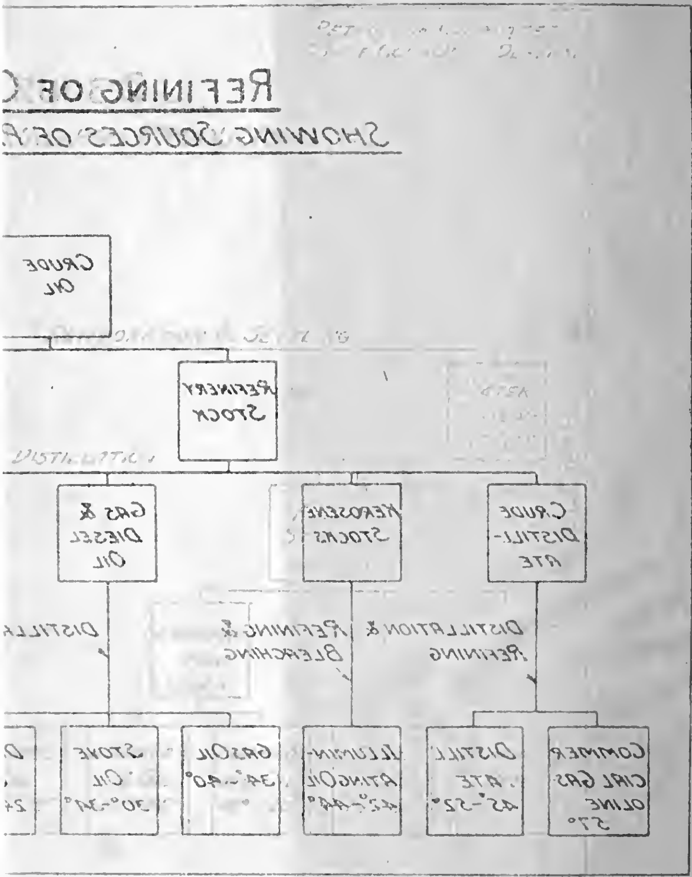
(In thousands of barrels.)

Name of company	Name of refinery	Input, 1916		Estimated input for 1917	Maximum capacity yearly
		Amount	Gravity, degrees Baume		
Standard Oil Company	Richmond	15,500	21.3°	15,880	21,900
	El Segundo	7,260	25.6°	9,880	10,950
	Bakersfield	8,540	26.2°	8,130	7,300
	Totals	31,300		33,890	40,150
Associated Oil Company	Avon	7,040	25.4° to 26°	6,780	8,030
	Gaviota	890	19° to 24°	590	910
	Amalgamated	1,190	14° to 23°	1,300	3,290
	Totals	9,120		8,670	12,230
Union Oil Company	Oleum	4,880	60%—24° to 27°; 40%—14° to 16°	4,040	8,030
	Maltha	630	24° to 27°	460	1,100
	Avila	3,110	80%—20°; 20%—17°	3,230	6,200
	Brea	2,150	19° to 22°	2,610	3,650
	Santa Paula	190	25°	190	290
	Naranjal Reduction Works	980	20°	1,060	1,100
	Totals	11,940		11,590	20,370
Shell Company of California	Coalinga	540	22° to 24°	690	730
	Martinez	5,000	22° to 27°	5,100	5,480
	Totals	5,540		5,790	6,210
General Petroleum Company	Vernon	*3,400		3,400	7,300
Miscellaneous		*4,380		4,380	*8,760
	Grand totals	65,680		67,720	95,020

*Estimated.



PETROLEUM COMMITTEE
STATE COUNCIL OF DEFENSE
CRUDE OIL
PRINCIPAL PRODUCTS
CRUDE OIL
DEHYDRATION & SETTLING
WATER & SEDIMENT
REFINERY STOCK
DISTILLATION
FUEL STOCK
LUBRICATING STOCK


REFINING OF C
SHOWING SOURCES OF P
CRUDE OIL
REFINERY STOCK
GAS & DIESEL OIL
KEROSENE STOCKS
CRUDE DISTILL-ATE
DISTILLATION & REFINING
REFINING & BLEACHING
COMMERCIAL GASOLINE 57°
DISTILLATE 45°-52°
ILLUMINATING OIL 42°-44°
GAS OIL 34°-40°
STOVE OIL 30°-34°

In the topping plants, where the products obtained are distillates and fuel oil, the distillation is carried to a point where the distillates are passed through a compressor, which indicates by its gravity that the oil remaining in the still will have a flash-point of about 150° F.

The fuel oil remaining can be stored with safety, and is pumped through a cooler into the proper tanks for distribution to points of use.

The refineries of the state have improved their methods, as a result of experiment, until greatly increased yields of gasoline and lubricants are now obtained from the oil treated.

V. *Detail of Present Refinery Practice.*

1. Input.

Table 15 shows the input into the California refineries in 1916 and the first four months of 1917, while Table 16 shows the present total monthly output from these refineries.

TABLE 16.

California Refinery Output.

(Average monthly barrels of 42 gallons. January-May, 1917.)

Gasolene over 56° Baume	430,000
Distillates, 36°-52° Baume	410,000
Kerosene, 42° Baume	310,000
Lubricants	105,000
Asphalt and road oil	115,000
Total of refined products	1,370,000
Unaccounted for	30,000
Residuum	4,000,000
Used in refining (residuum)	230,000
Total refinery input	5,630,000

At the present time, approximately 60 per cent of the California oil is subjected to some degree of refining before being utilized, and it is evident from the statistics in the tables cited above and in Chapter IV that practically all the oil over 20° Baume, now produced in this state, is at least partially refined, and that the production of gasoline of the present gravity (57° Baume) from California oil has almost reached a maximum, if only the past method of refining be considered. Plate XXI shows in outline the general treatment of California oil.

2. Separation of Water.

If the water which is produced with the oil is in a free state, it can be partially separated by settling, except in cases as in the Casmalia Field, where the oil is too heavy for such gravity separation. In many cases, however, the water produced with the oil is in the form of an emulsion, and then requires special treatment. Four systems have been used for this purpose:

First: Dehydration by direct heat. In this process the oil emulsion is pumped through coils of pipes mounted in a brick chamber between brick furnaces. The temperature of the oil is raised above the boiling point of water, when an explosive action takes place separating the globules of water from the enveloping film of oil.

Second: Dehydration by indirect heat. In this case the emulsion is treated by steam coils to a temperature of near 200° F., when the oil rises to the top of the water.

Third: Dehydration by compressed air. Air pressure, sufficient to overcome the weight of the petroleum, is heated to a high temperature in a boiler furnace, and is then distributed through small openings into the oil tank. The heat in the air is sufficient to convert the water into steam, and thus liberate the oil.

Fourth: The Cottrell process, which depends upon the static discharge when a high voltage current is passed through the oil.

3. Distillation of Oil.

Following the dehydration of the oil, it is treated in stills of various types. The type in common use consists of horizontal steel shells up to 1,000 barrel capacity set in brickwork and heated by oil or gas burners, the arrangement being somewhat similar to the ordinary oil-fired boiler. From the still the vapor is conducted through pipes to the condenser, which usually consists of a coil of pipes set in a circulating current of water. From the condenser the liquid distillate is conducted to the "tailhouse," where gravity samples of the distillate may be taken, and from there it is distributed for further treatment.

There are two methods of operating the stills. The first is known as the intermittent, and the second as the continuous system.

In the first method, a charge of crude oil is placed in the still, and the temperature is increased and the distillation continued until the process has reached the desired point. The residuum is then withdrawn and a fresh charge of oil delivered. If the distillation is carried to completion, asphalt or coke will be the final product.

In the continuous system, several stills are connected and run in series by charging the first still slowly and pumping from the last one. Each still is heated to a higher temperature than the preceding one, so that different boiling-point fractions are obtained from each still in the battery.

The Trumble plants, so called from the inventor of the process, are operated by the continuous system, but small pipe retorts are used instead of the larger stills used in the intermittent process.

The special features of the Trumble process are the attempt to save heat and the small furnaces required. The oil is heated in passing through twelve-inch pipe coils about twelve feet long, placed in a

longitudinal brick furnace. The heated oil then passes to the top of the evaporating chamber, where it is forced, by means of conical spreaders, to flow down the inside surface of the still shell, which is heated on the outside by escaping flue gas. The gas and residuum produced in this chamber then flow through separate pipes placed within larger ones, and the oil, which is to be treated in the retort, flows in the annular space between these pipes, so that the incoming oil is heated, while the outgoing products are proportionally cooled.

4. Further Treatment of Distillates.

In all refineries the distillates, as they come from the different types of condensers and are separated in the "tailhouse," require further refining.

The gasoline stock is pumped into a cylindrical still provided with a perforated steam coil placed a few inches from the bottom of the still. The heat required for re-evaporation is introduced and controlled through the steam, and, by this means, destructive distillation, or cracking of this distillate, is prevented. The gravity of gasoline produced in California has steadily decreased in the last ten years from 72° Baume to approximately 57° Baume. It is now recognized that gravity of gasoline is not as important in determining its value as the control of the boiling point.

Large quantities of gasoline are made from the distillate produced in the "topping plants." Many of the heavy crude oils produced in California contain a small proportion of light gravity oil, which may be easily removed in a battery of continuous stills. These "tops," as the light distillate is known, are usually about 50° Baume, and may be further refined to produce gasoline and gas oil for the manufacture of artificial gas, or they may be blended with high gravity casinghead gasoline.

The kerosene stock is further refined by using a low fire under an ordinary cylindrical still, while the temperature is controlled by introducing live steam into the still. The kerosene is then treated with about 2½ per cent fuming sulphuric acid, is thoroughly agitated with air, the resulting sludge drawn from the agitator, and the kerosene washed with water, the acid remaining in the oil is neutralized in a solution of caustic soda. The desired flash test is secured by careful distillation and the removal of oil lighter than 46° Baume.

As indicated in an earlier paragraph, the demand for kerosene is fully supplied, and many of the refineries of the state do not attempt its manufacture.

The various intermediate distillates, such as gas oil, stove oil and Diesel fuel oil, do not require further treatment before marketing. These oils sell at a comparatively low price.

The oil from which the various lubricants are obtained must be carefully distilled, and are first freed from oils lighter than 24° Baume to improve the lubricating quality of the finished oil. The temperature of the process is controlled either by the use of steam, or by refining under a partial vacuum, in which case the products are given off at a lower temperature than when treated at ordinary pressures. The lubricating products are agitated with sulphuric acid to remove the asphaltum and tarry matter, and then with caustic soda and water. They are frequently filtered through boneblack or fuller's earth to lighten the color and to improve the lubricating value. Cylinder oils are among the most expensive products from petroleum.

At some of the refineries of the state high-grade medicinal oils are manufactured. These oils are expensive, but are in great demand, and have taken the place of the Russian oils formerly imported into America.

VI. *Future Development of Refining Process.*

If the conclusions in Chapter VIII as to the increased use of California gasoline and lubricants in the Eastern states are correct, then further improvement must be developed in the refining process for the production of additional quantities of gasoline, and greater quantities of low gravity oil will be treated for lubricants.

1. Increased Gasoline Output.

Increased gasoline output may be accomplished by one, or both, of two methods. First: By the lowering of the gravity of the gasoline, as has been done in the past, which, with a corresponding change in carburetor construction, might be carried down to approximately the gravity of kerosene. In this connection it is interesting to note that, with the present grade of gasoline, a decrease of 1° Baume in the gravity of the gasoline produced will result in an additional yield of 10 to 15 per cent of gasoline. A second method of increasing the quantity of gasoline is through the development of a commercial "cracking" process. Essentially, the "cracking" process, as defined by Rittman, consists in heating oils to such a temperature that the heavy molecules decompose into lighter molecules with the production of mixtures of lower boiling point. This may be accomplished by long exposure to a degree of heat below the boiling point of a particular hydrocarbon, resulting in its dissociation or partial alteration. The control of the reaction which takes place is very delicate, and depends upon the absolute control of the temperature and pressure. A number of processes have been completely worked out in refinery laboratories, and have been partially developed for the commercial "cracking" of heavy oil into gasoline hydrocarbons. The first attempts at "cracking"

Delivery	Remarks
Refinery	Plant started end year 1916
Refinery	Plant started end year 1916
Avila Refinery	
Avila Refinery	
Avila Refinery	
Avila Refinery	
Los Angeles	
Bakersfield and Taft	
Avila Refinery	Started May 1917. Will produce 24 bbls. daily.
Avila Refinery	Now under construction.
Los Angeles	Now under construction.
Bakersfield, Taft, etc.	
Refinery	Now under construction.
Refinery	Started early part year 1917.
Refinery	
Refinery	
Refinery	Started early part year 1917.
Refinery	
Refinery	
Avila Refinery	
Avila Refinery	
Avila Refinery	
Avila Refinery	
Avila Refinery	
Santa Maria, etc.	
Los Angeles, etc.	
Los Angeles, etc.	
Sold as gasoline, gas, etc.	
Los Angeles, etc.	Now under construction. Will produce 8 bbls. daily.
Refinery	
Refinery	
Refinery	
Refinery	
Refinery	
Locally	
Locally	
Refinery	
Refinery	
Refinery	Now under construction.
Locally	
Refinery	
Refinery	
Own use	

were undertaken at atmospheric pressures. In English patents, temperatures as high as 900° C. have been used. In the McAffe patented process, aluminum chloride is used as a catalyzing agent. This process has been tested by the Gulf Refining Company on oils from the Mid-Continent and Gulf Coast fields, but, as reported, without commercial success.

The most important and promising methods thus far introduced for the "cracking" of California petroleum are the Burton process and modifications of the Rittman process. The first is controlled by the Standard Oil Company, and has been successfully used for years in Eastern refineries. At present the Standard Oil Company of California has a battery of ten stills in their Richmond refinery, using this method in the manufacture of gasoline. The process is limited to distillates with a boiling point of 400° F. or above. The operation is carried on in large stills subjected to this temperature, and as the stills are directly connected to the condenser and the pressure is controlled by the discharge from the condenser, a pressure of four to six atmospheres is maintained throughout the system. The condensate from this "cracking" is finally distilled under atmospheric pressure to form gasoline, and the residuum may be returned for repeated recracking.

In the Rittman process the "cracking" takes place in small tubes, and the material treated is kept in a gaseous condition throughout the entire operation. High temperatures of 500 to 800° C. have been used with various pressures from partial vacuum up to 300 pounds per square inch. The difficulties with this process have been the difficulty of control of the high temperatures and the formation of a carbon deposit inside the tubes. One modification of the scheme now used with apparent success at one of the California refineries for the treatment of low-grade distillate is the introduction of live steam into the tubes for the control of temperature and pressure.

At the present time all the California refining companies are experimenting with "cracking" processes, and inasmuch as various methods have been successfully worked out in the refinery laboratories and in miniature refineries, it seems certain that in time the mechanical difficulties which have stood in the way of large scale commercial success will be overcome.

VII. *Casinghead Gasoline.*

In the last eight years several processes for the production of casing-head gasoline from wet gas have been developed. These methods serve a double purpose, since they result in the saving of a valuable constituent of the gas, which was formerly wasted, and also add about 10 per cent to the present state production of gasoline. Table 17 is a statement of

the casinghead gasoline plants in California, with data relating to their situation, methods used, volume of their output and its disposition.

The principal processes used in the production of gasoline from wet gas are: First: compression and cooling, and, second, absorption. The compression and condensation of gasoline vapors from natural gas is exactly analogous to the compression of air and the accidental condensation of water vapor in the air receiver. The mechanical apparatus employed is ordinarily a two-stage compressor. The gas is cooled by running it through coils sprayed with water, and then allowing it to stand from pressures of 250 pounds down to 50 pounds by forcing it to operate the compressor. In the absorption process, natural gas is forced in pipes into intimate contact with a heavy oil which carries no gasoline. The gas deposits its gasoline vapors in the oil, and this gasoline is subsequently recovered by distillation at the refinery.

It is probable that the total casinghead gasoline production for 1917 will amount to 600,000 barrels, of which about 500,000 barrels will reach the market through the refineries, and the balance of 100,000 barrels will be marketed directly after blending with low-grade distillate. Dr. Rittman has estimated that the production of casinghead gasoline in the United States is approximately 5,000,000 barrels for 1917.

SUMMARY.

The following are the principal facts in regard to the refining of California oil:

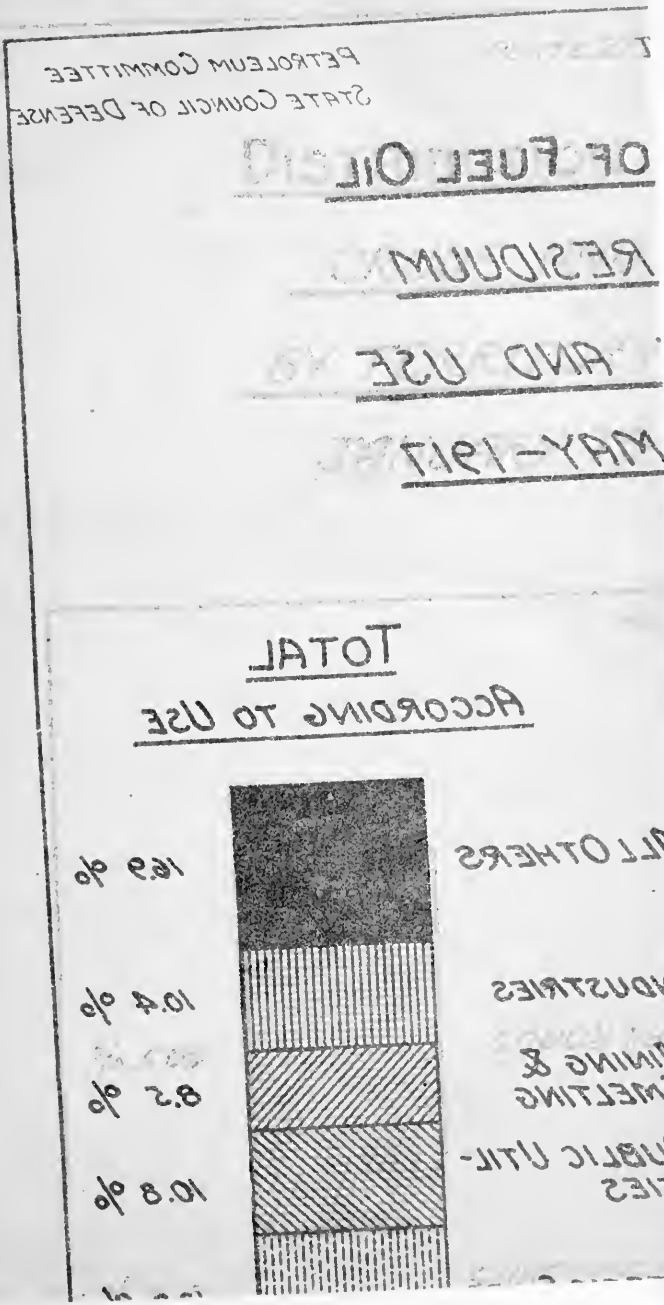
First: Approximately 60 per cent of the oil of the state is now refined in part before being utilized.

Second: The principal present market demand is for gasoline and residuum for fuel.

Third: A greatly increased demand for gasoline and lubricants may be anticipated in the future.

Fourth: This increased demand will result in the refining of a large proportion of the oil and a smaller quantity of crude burned as fuel.

Fifth: Improved methods of refining are being developed which will increase the yield of gasoline and lubricants per barrel of oil treated.



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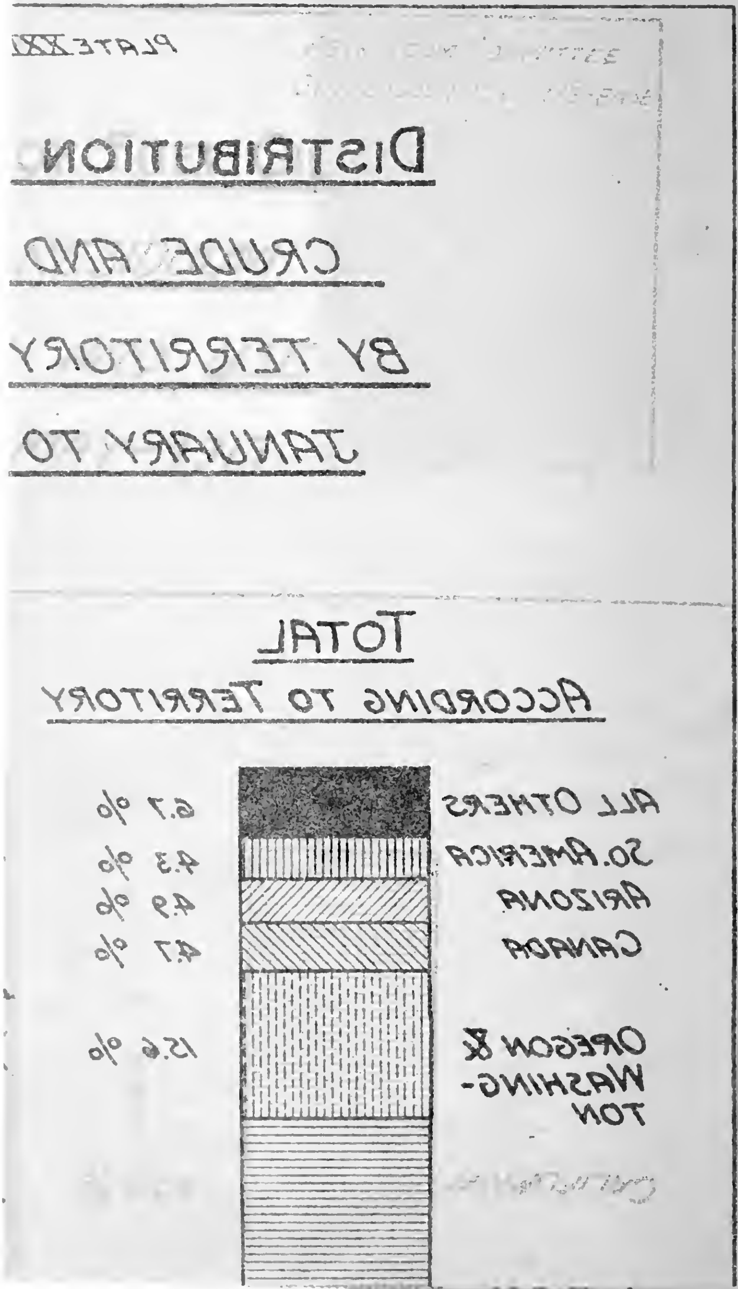
PLATE XXI
DISTRIBUTION
CRUDE AND
BY TERRITORY
JANUARY TO
TOTAL
ACCORDING TO TERRITORY
ALL OTHERS 6.7 %
SO. AMERICA 4.3 %
ARIZONA 4.9 %
CANADA 4.7 %
OREGON & WASHING-TON 15.6 %

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CHAPTER VIII.

UTILIZATION.

I. *Character of Pacific Coast Fuel Situation.*

The utilization of California oil offers a very fascinating study. The more so, because up to the time of this investigation no general information was available as to either the exact territory or use to which oil and its products were distributed. The larger oil companies in the operation of their own business, have always been in complete touch with the markets, and have developed new contracts each year until the present oil shortage compelled a change in this policy. But each of these marketing companies lack definite knowledge as to the business of their rivals, and only by obtaining confidential information from each company, and assembling all items of sale to reach a total figure, could the committee create a representative picture of this phase of the industry, as shown in Tables 19 and 20 and Plates XXII, XXIII, XXIV, XXV.

The entire Pacific coast must be considered in viewing these statistics on the use of California oil, as the fuel situation in the Western states and on the Pacific is fundamentally different from that in other parts of the United States. On the Atlantic coast, throughout the Mississippi Valley, and even in the Rocky Mountains, both coal and oil are available. In fact, the great Mid-Continental oil fields, through extensive pipe lines, are tributary to the commercial centers of the Atlantic and Gulf coasts. Moreover, the relatively denser population of these Eastern states has demanded an enormous quantity of the manufactured products of oil. Gasoline, distillate and lubricants have become a familiar and necessary part of the daily life of the nation, and practically the entire output of the Eastern and Mid-Continental oil fields has been required to meet this demand. Coal has, therefore, remained the foundation-stone of industry and commerce as the fuel of universal use.

On the Pacific coast, the deposits of coal now developed and suitable for industrial use, aside from the coal fields of Washington and Vancouver Island are negligible, and the high transportation costs, with the difficulties of coastwise shipping would have combined to make the substitution of any economical fuel for coal an easy and rapid transition. And the remarkable development of the California oil fields following 1900, the early excess of heavy oil, suitable at the time only for fuel purposes, gave the rapidly expanding industries of the coast a satisfactory solution of their fuel problems. Unlike the situation in the East, the demand for the refined products of California oil was small, the proportion of distillates and lubricants taken from the crude

in the first days of refining was disappointing, and the ratio of crude of refining gravity to the heavier fuel grades was 10 per cent and less. These conditions combined to cause the widespread adoption of oil, which seemed a logical source of power and heat.

II. *Development of Fuel Oil Industry.*

The oil industry in California is still essentially a fuel oil industry, and, while the proportion of refined products has steadily increased, the immediate problem occasioned by the shortage today is that of supplying for the entire Pacific coast adequate fuel for industrial and locomotive boilers, rather than one of furnishing supplies of gasoline, kerosene and distillate. If the problem is to be solved efficiently, in the future crude oil of refining quality must not be sold as fuel. Secretary of the Interior Franklin K. Lane, in his annual report for 1915, stated that: "An absolute government would prohibit a barrel of oil being used for fuel before every product of kerosene, gasoline and other available constituents have been taken from it." This statement, which is unquestionably true, has been widely quoted, and has been ably discussed, with reference to California, by Mr. M. L. Requa in Senate Document 263.

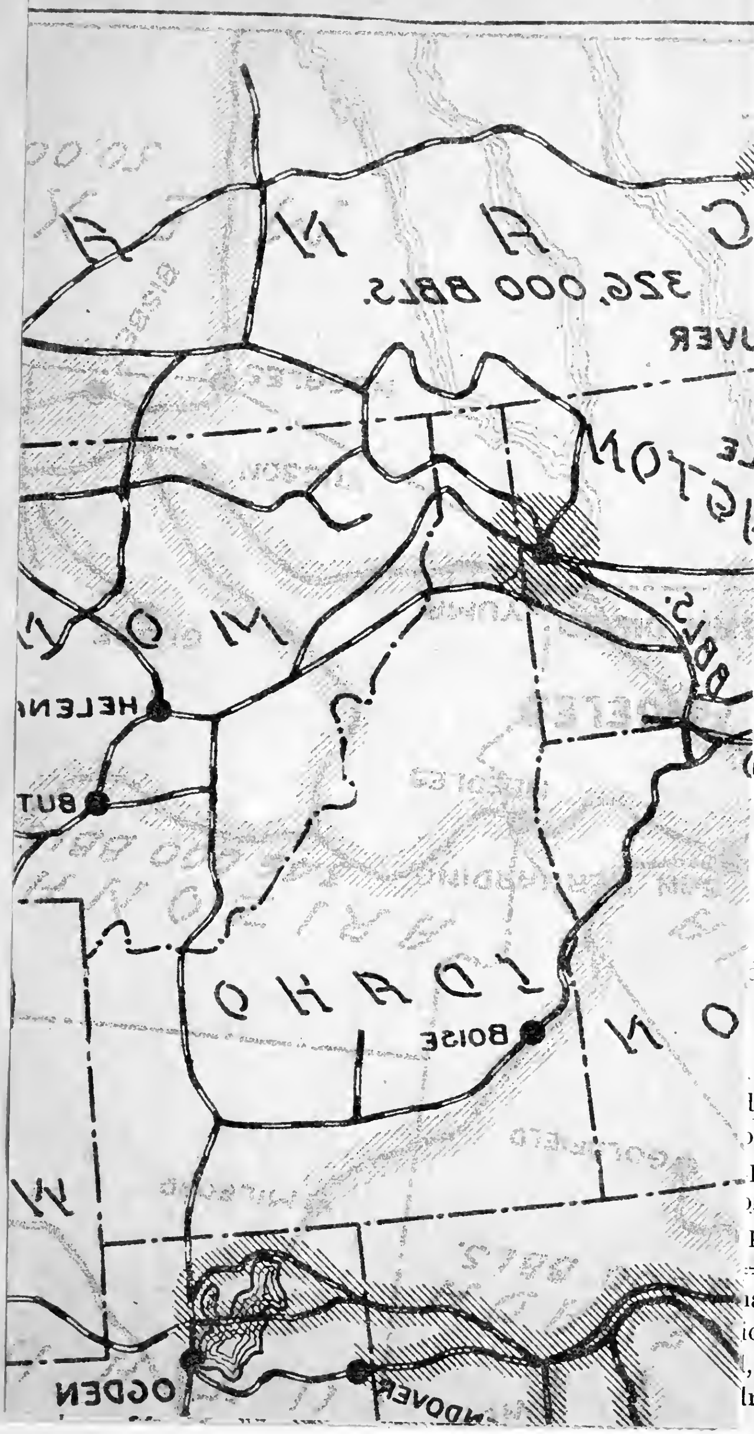
TABLE 21.

TOTAL AND NET CONSUMPTION OF CALIFORNIA OIL.

(Average monthly in barrels of 42 gallons, January-May, 1917.)

		Barrels per month	Total
Gross production		8,000,000	
Drawn from storage		1,100,000	
Total consumption		9,100,000	
Field consumption and loss	260,000		
Pipe consumption and loss	210,000		
Refinery consumption and loss	260,000		
Total consumption		730,000	
Net consumption			8,370,000
Sold as crude oil		3,000,000	
Sold as residuum		4,000,000	
Total fuel oil			7,000,000
Refinery products			1,370,000
Total			8,370,000

A total of 9,100,000 barrels of California oil is now consumed monthly, of which approximately 8 per cent is used as fuel oil in the oil industry itself. Of the net amount remaining, over 80 per cent



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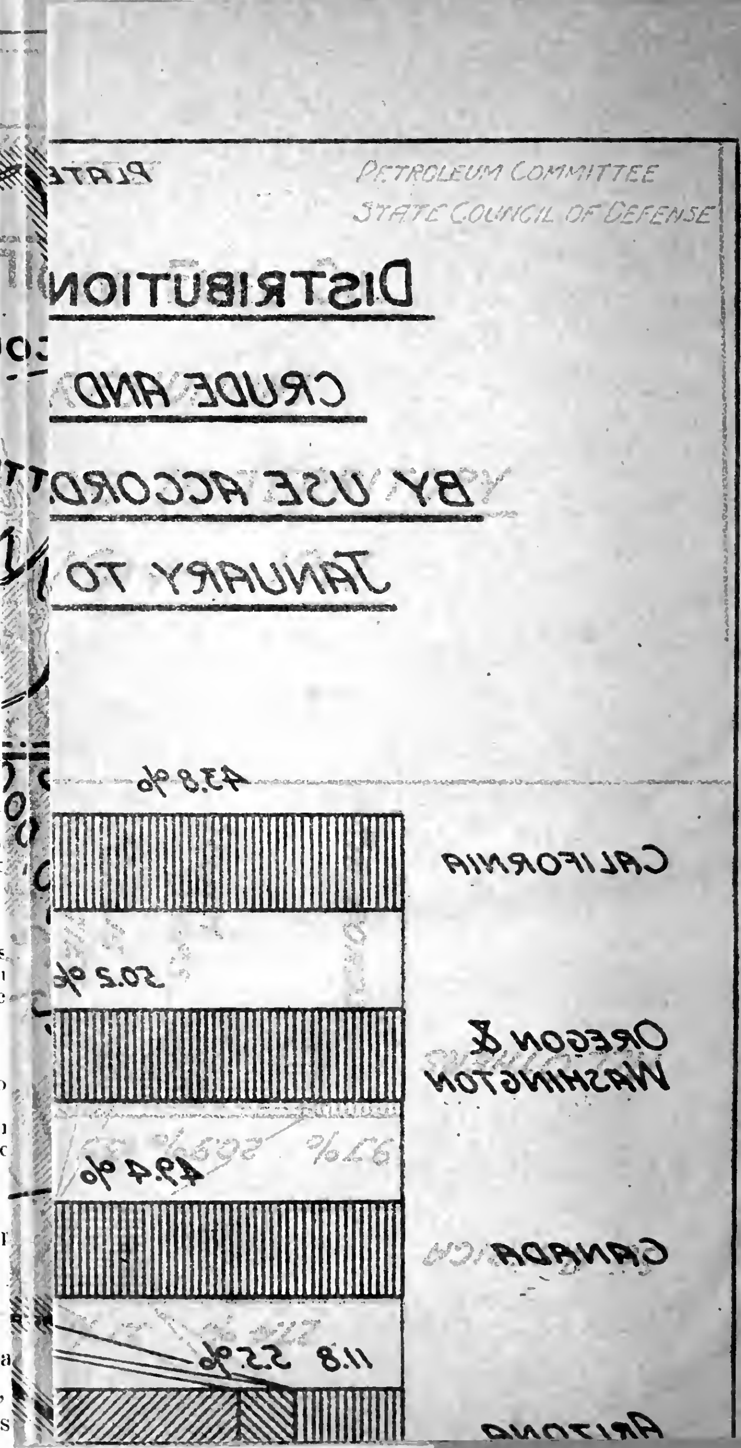

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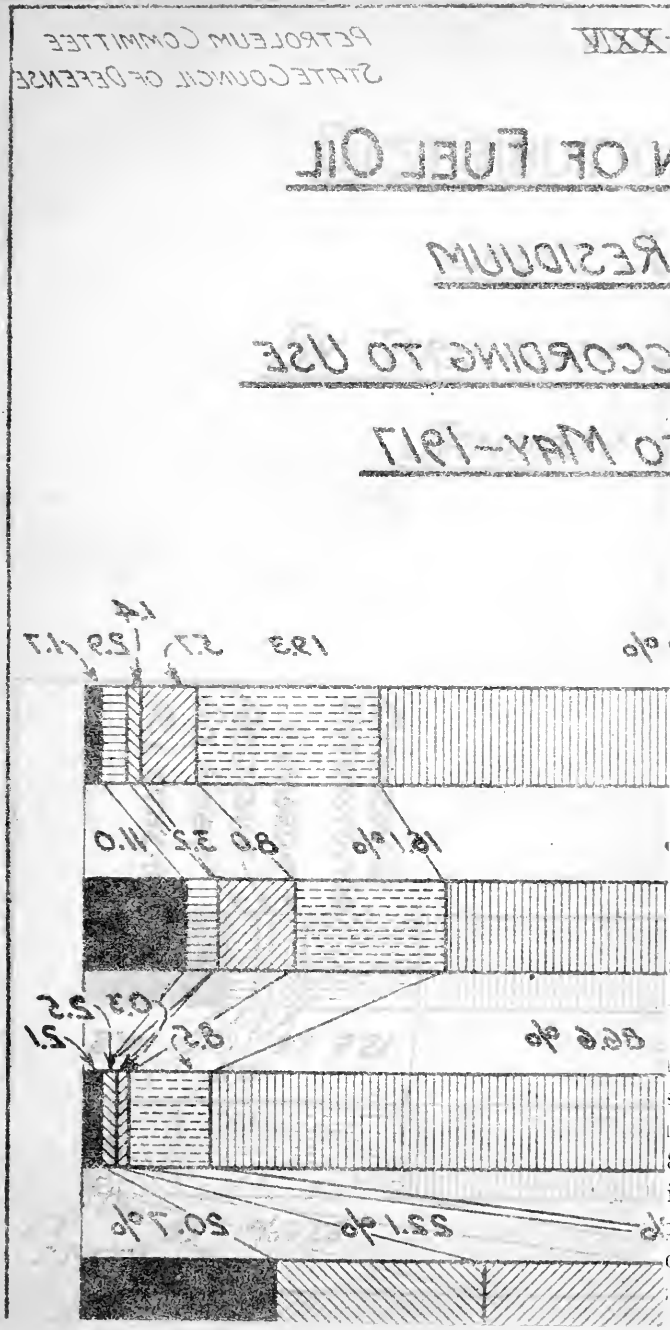

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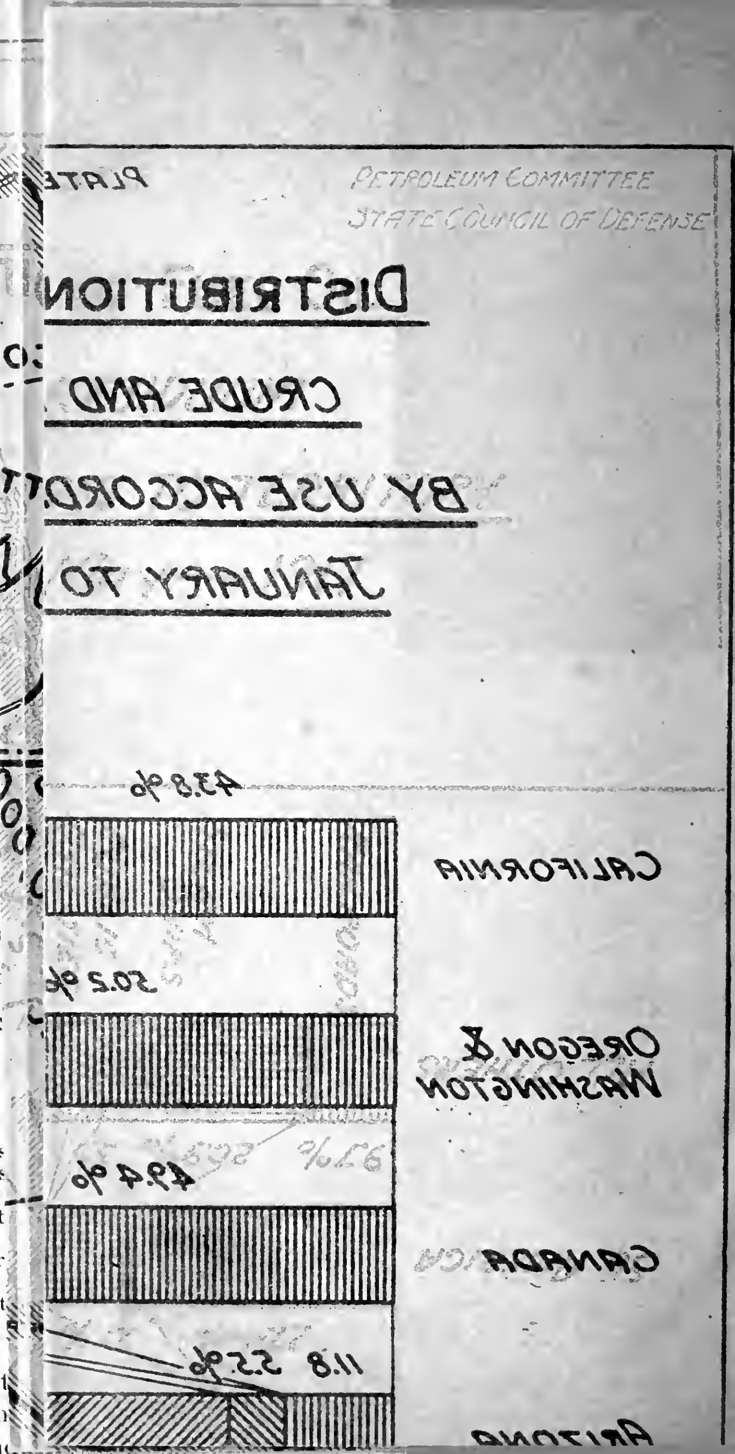

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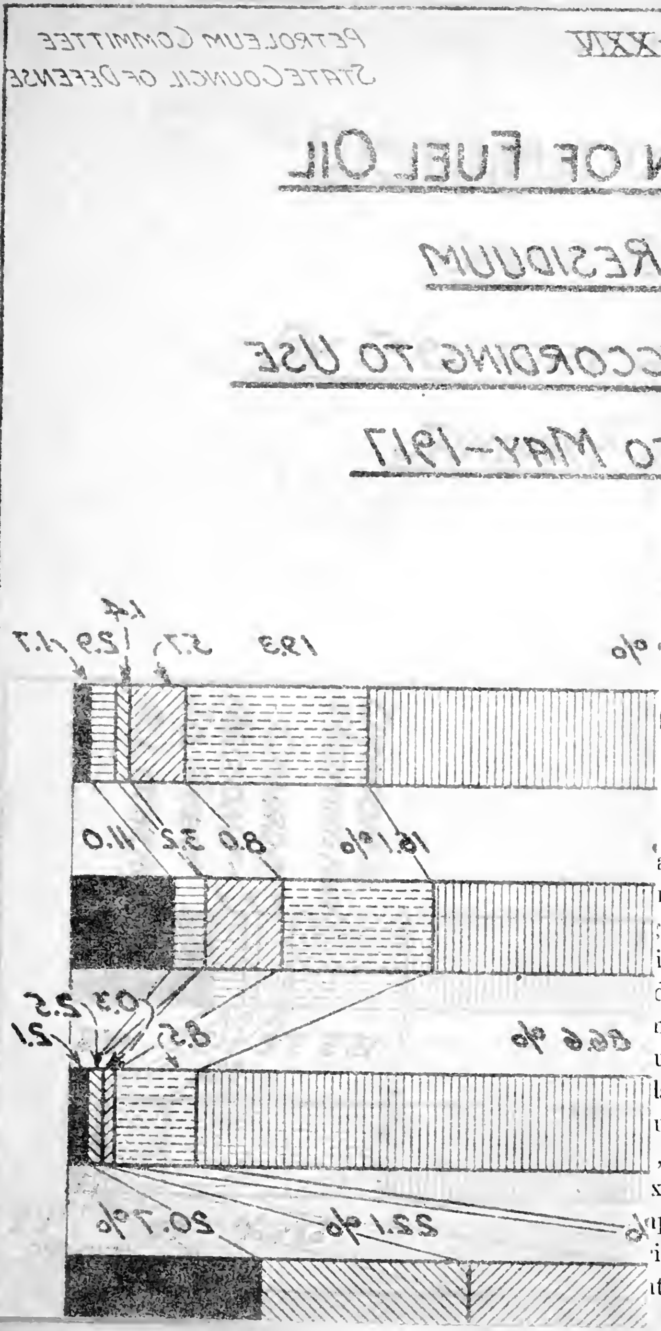

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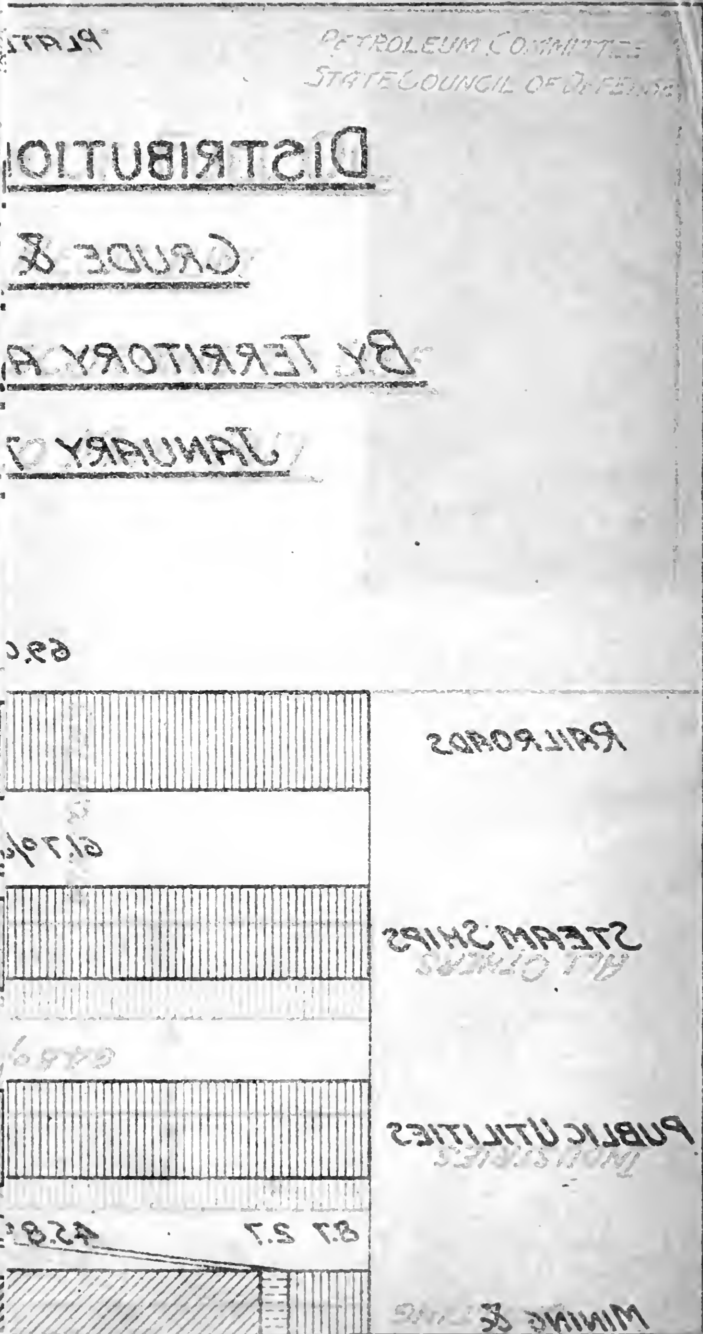

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is burned under boilers. This should be contrasted with the oil situation in the eastern portion of the United States, where approximately 80 per cent of the production is sold as refined products, and only 20 per cent is used as fuel. The relatively small amount of the oil of California, which is sold in the form of refined products, is shown in Plate XXVI. However, of the 7,000,000 barrels of fuel oil burned monthly, 4,000,000 barrels are refinery residuum remaining after the crude oil has given off gasoline, and, in some cases, gas oil, kerosene and lubricants.

The proportion of oil produced of over 20° Baume during 1916, with comparative figures for 1907, is shown below, and also by Plate XV.

	Oil under 20° Baume, barrels	Oil over 20° Baume, barrels
1907	36,000,000	4,000,000
1916	39,000,000	53,000,000

The corresponding increase in the proportion of oil refined is discussed in Chapter VII.

The realization of the limited oil resources of the state has come only in the last years, when the tremendous expansion of the automobile industry, the growing demands of an export trade, fostered when supply threatened to flood home markets, and now grown burdensome, and the urgent needs of the nations at war, have shown that production once supplying an excess for storage has been outstripped by consumption—with rising prices, efforts to increase output materially have failed, and the shortage is an actuality.

III. *Rapid Growth of Pacific Coast Industries.*

The rapid growth of the industries of the Pacific coast, and the attendant expansion of the Western railroads, all oil burning since 1906, is clearly the predominate factor in the present shortage. The chief use of fuel oil, as indicated in Table 19, is for transportation purposes. Plate XXII A shows the Pacific coast railroads, the shaded portion being the divisions operated by California fuel oil; the map also shows the chief industrial centers where there is heavy consumption of oil. As an index to the increased use of fuel oil by railroads of the state, it will be noted in Table 22 that in 1906 the total consumption was 10,864,000 barrels, while the use for 1917 is estimated at 21,844,000 barrels. In 1902, the Southern Pacific Railway used approximately 2,000,000 barrels of oil, while for 1917 the estimated consumption is 16,000,000 barrels for this one company. During this period, the traffic efficiency of the railroad has increased so that the freight drawn

one mile by the power developed from one barrel of oil has grown from 750 tons to 930 tons. During the period of the last ten years, the total consumption of oil by the following railroads has increased on an average of 10 per cent per year: Southern Pacific, Santa Fe, Western Pacific and Northwestern Pacific.

A measure of the general increase in use of California oil is given by the increased shipments from the fields year by year. This shipment, as shown in Plate XXVII, has grown at the average rate of 15 per cent per annum for the last fifteen years, and while the demand in 1914 and 1915 fell below this ratio, the rate of increase in 1916 and the first half of 1917 is ample proof that a greatly increased demand for California fuel oil and the refined products can be anticipated. The rise in price will discourage this demand to some extent, but it must be remembered that developed industries must continue to burn oil at any price as long as no other suitable fuel is available.

IV. *Utilization of Fuel Oil.*

At the present time, in addition to railroad use, the Pacific steamship lines, both those operating along the coast and those engaged in export trade, and public utilities, which include the telephone, gas and electric, water and street railway companies, are all large consumers of fuel, and are now wholly dependent upon oil. The varied use of oil in the industries is shown by the fact that the marketing companies have large contracts with mining and smelting companies, the manufacturers of explosives, chemicals, fertilizers, salt and soap, with tanneries, steel works and foundries, shipbuilders, stonequarries, lime and cement plants, lumber and planing mills.

In the production of food, fuel oil is used in farming for pumping and traction engines, in sugar refineries, ice plants, restaurants, bakeries and creameries. Under miscellaneous, in Plate XXV, is included the heating of buildings, such as hotels, apartment houses, offices, schools and hospitals, the United States government, state and country demands, the oil jobbers, the wineries, breweries and distilleries, construction and reclamation work, printers and publishers, the packing houses, silk, felt, cotton and wool mills.

In Plates XXII to XXV, and Table 19, the general distribution of California fuel oil is shown in detail.

V. *Increase in Shipments.*

As indicative of the expansion of industries outside of California, dependent upon fuel oil, the following facts are worthy of note: Since 191[illegible] the quantity of oil required for the operation of mines and smelters in Nevada and Arizona has more than doubled.

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Totals	1,542,899	18,514,799	1,615,233	19,382,801	1,820,362	21,844,351	1,958,858	24,361,914

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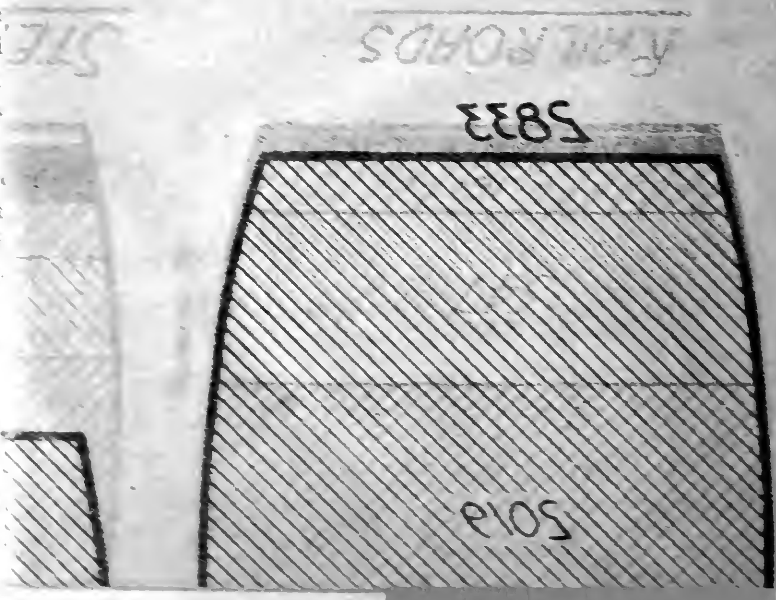


TABLE 22.

ANNUAL AND AVERAGE MONTHLY CONSUMPTION OF FUEL OIL BY PACIFIC COAST RAILROADS.

Company	1905		1906		1907		1908		1909	
	Average monthly	Total for year	Average monthly	Total for year	Average monthly	Total for year	Average monthly	Total for year	Average monthly	Total for year
A., T. and S. F.	207,849	2,494,188	230,533	2,766,396	277,430	3,329,158	239,888	2,878,656	291,313	3,495,760
Northwestern Pacific					31,539	378,463	31,986	383,831	32,347	388,168
Los Angeles and Salt Lake	20,433	245,201	32,710	392,515	53,837	646,049	66,510	798,124	77,495	929,942
Southern Pacific			650,348	7,804,173	779,182	9,350,180	719,280	8,631,386	801,259	9,615,114
Western Pacific										
Totals	228,282	2,739,389	913,591	10,963,084	1,141,988	13,703,850	1,057,664	12,691,997	1,202,414	14,428,984

Company	1910		1911		1912		1913	
	Average monthly	Total for year	Average monthly	Total for year	Average monthly	Total for year	Average monthly	Total for year
A., T. and S. F.	337,102	4,045,221	368,848	4,426,176	408,158	4,897,407	384,674	4,616,092
Northwestern Pacific	33,757	405,087	32,869	394,432	34,803	417,637	36,709	440,506
Los Angeles and Salt Lake	66,348	796,177	113,934	1,367,206	113,553	1,362,640	120,249	1,442,998
Southern Pacific	932,472	11,189,662	908,851	10,906,209	1,013,228	12,158,731	1,065,166	12,781,992
Western Pacific							76,099	913,190
Totals	1,369,679	16,436,147	1,424,502	17,094,023	1,569,742	18,836,415	1,682,897	20,194,778

Company	1914		1915		1916		1917	
	Average monthly	Total for year	Average monthly	Total for year	Average monthly	Total for year	Average monthly (to May 1st)	Total for year (estimated)
A., T. and S. F.	343,912	4,126,949	368,625	4,423,498	405,985	4,871,818	450,709	5,421,330
Northwestern Pacific	41,447	497,370	41,731	500,771	45,857	550,290	41,492	594,428
Los Angeles and Salt Lake	108,414	1,300,972	105,250	1,263,000	103,553	1,242,631	105,513	1,266,156
Southern Pacific	981,759	11,781,106	1,026,523	12,318,279	1,176,711	14,120,538	1,272,060	16,000,000
Western Pacific	67,367	808,402	73,104	877,253	88,256	1,059,074	89,084	1,080,000
Totals	1,542,899	18,514,799	1,615,233	19,382,801	1,820,362	21,844,351	1,958,858	24,361,914

The Canadian demand has increased four and one-half times since 1909, and, though coal is comparatively cheap, the greater convenience, assurance of supply and economies of operation afforded by oil have made its continued use certain in a majority of instances. Fifty per cent of the consumption in Canada and in Washington and Oregon, supplied by California companies, is credited to the railroads. The Canadian government requires the burning of oil through certain forest reserves, as a matter of fire precaution, and, for the same reason, our Northwestern railroads are further influenced to use of oil as fuel.

The market is still expanding, as is shown by the shipping records of Northwestern ports, from Portland to Alaska, where an average of 1,520,000 barrels monthly was docked the first five months of 1917, as compared to an average of 1,460,000 barrels for the corresponding period of 1916.

The annual shipment of oil to Alaska has increased two and one-half times since 1909, while the annual shipment to Hawaii has doubled in the last ten years.

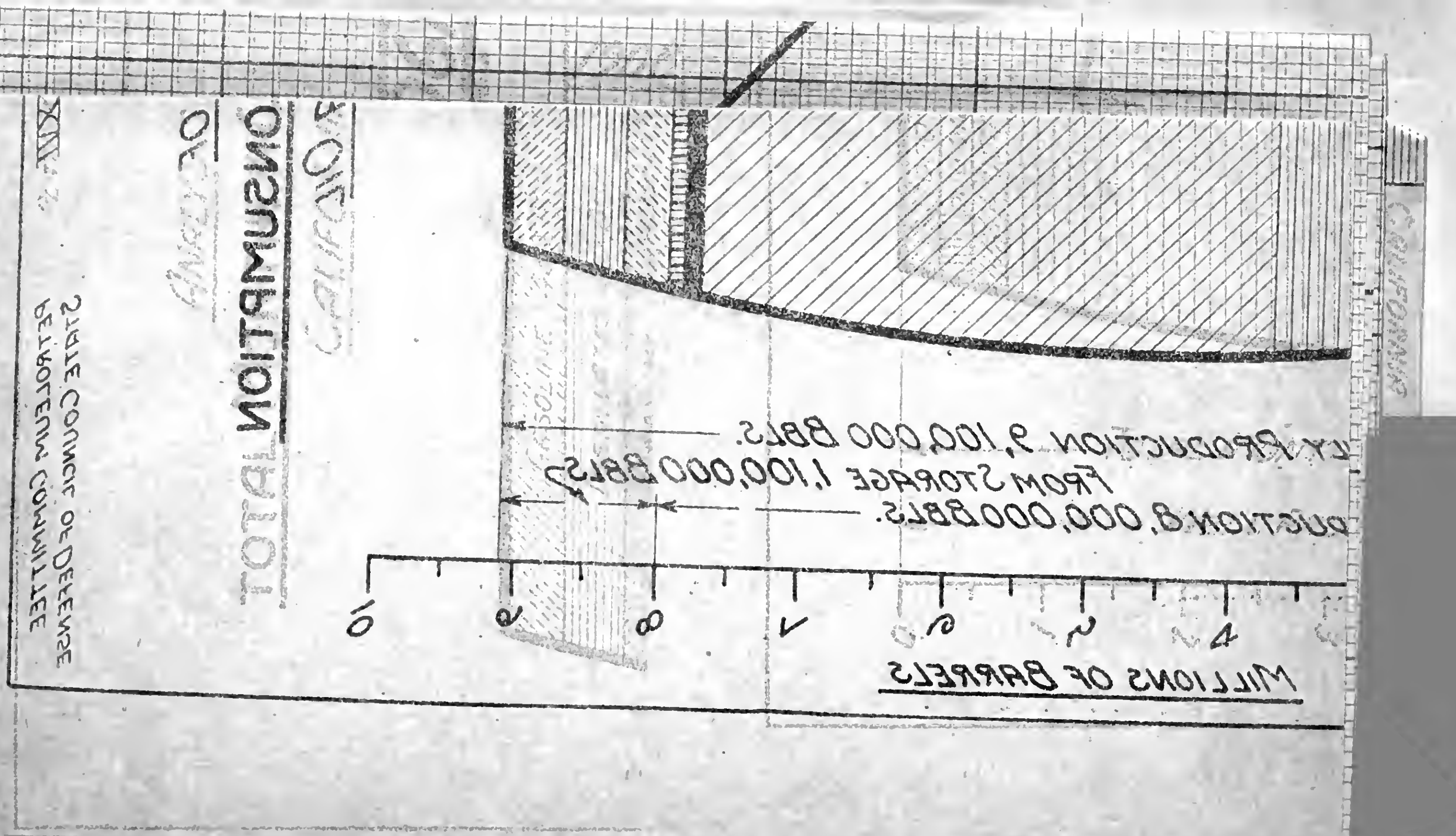
VI. *Utilization of Refined Products.*

California uses 58 per cent of its entire gasoline production, 41 per cent of the distillates, motor oils and tops, 30 per cent of the kerosene. It is evident that the greater amount of this gasoline consumed at home is purchased by automobile owners, and in that connection it is interesting to note the rapid increase in the number of motor vehicle registration in this state. The total of licenses issued in 1905 and 1906 was 8,732. In 1910, the number of automobiles in use was approximately 45,000. The total number of automobiles registered from 1905 to 1913, inclusive, was 123,582; the actual number in use at the latter date can not be determined. The registrations for 1914, under the new license system, were 122,100, which fairly represents the number in use. This was increased to approximately 200,000 in 1916.

The output of California gasoline is now approximately 430,000 barrels monthly, and the 60 per cent of home consumption would give 250,000 barrels for the automobiles of the state.

The parallel curve for the increase in automobiles in use over the United States is shown in Plate XXVIII, with the per cent of increase in gasoline production, and in crude oil production.

Approximately 110,000 barrels of lubricants are produced each month, marketed largely on this coast. Various grades of spindle, light, medium and heavy motor oils are refined, and the use is as diversified as are the industries which require lubricants in their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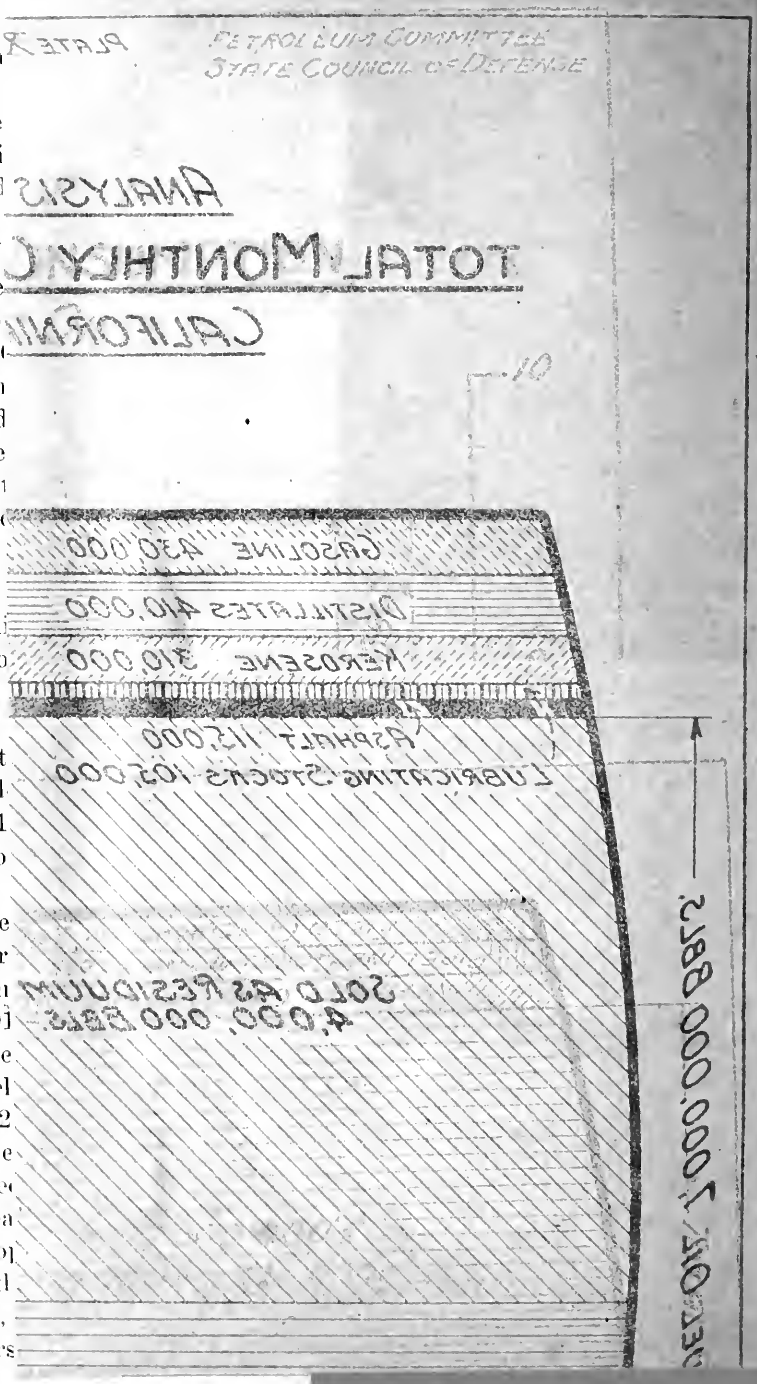

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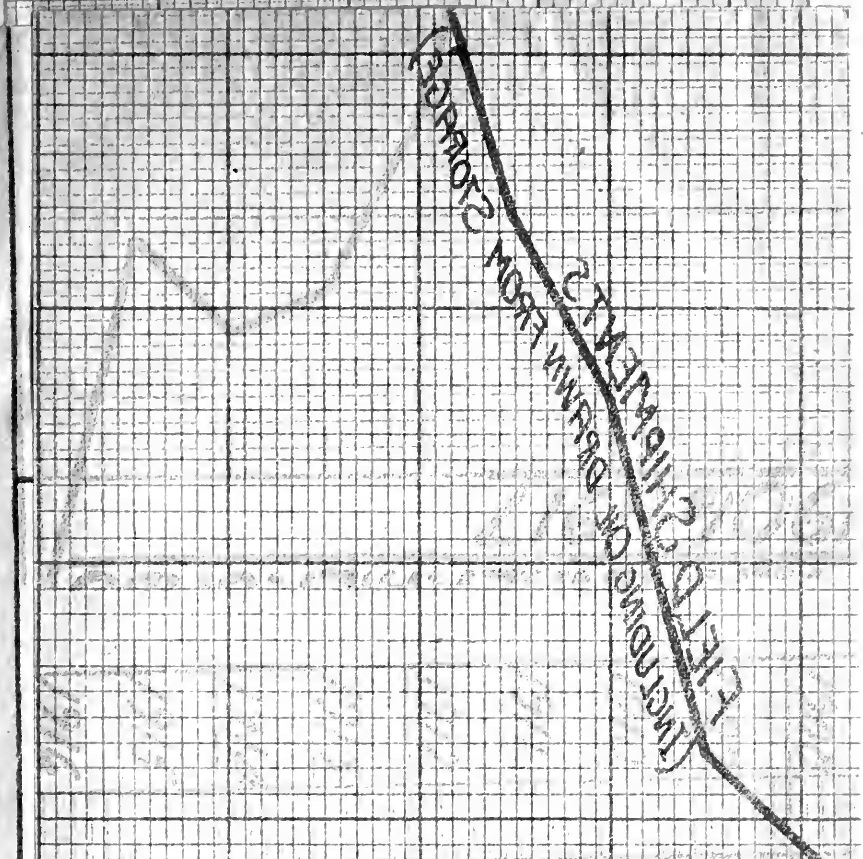

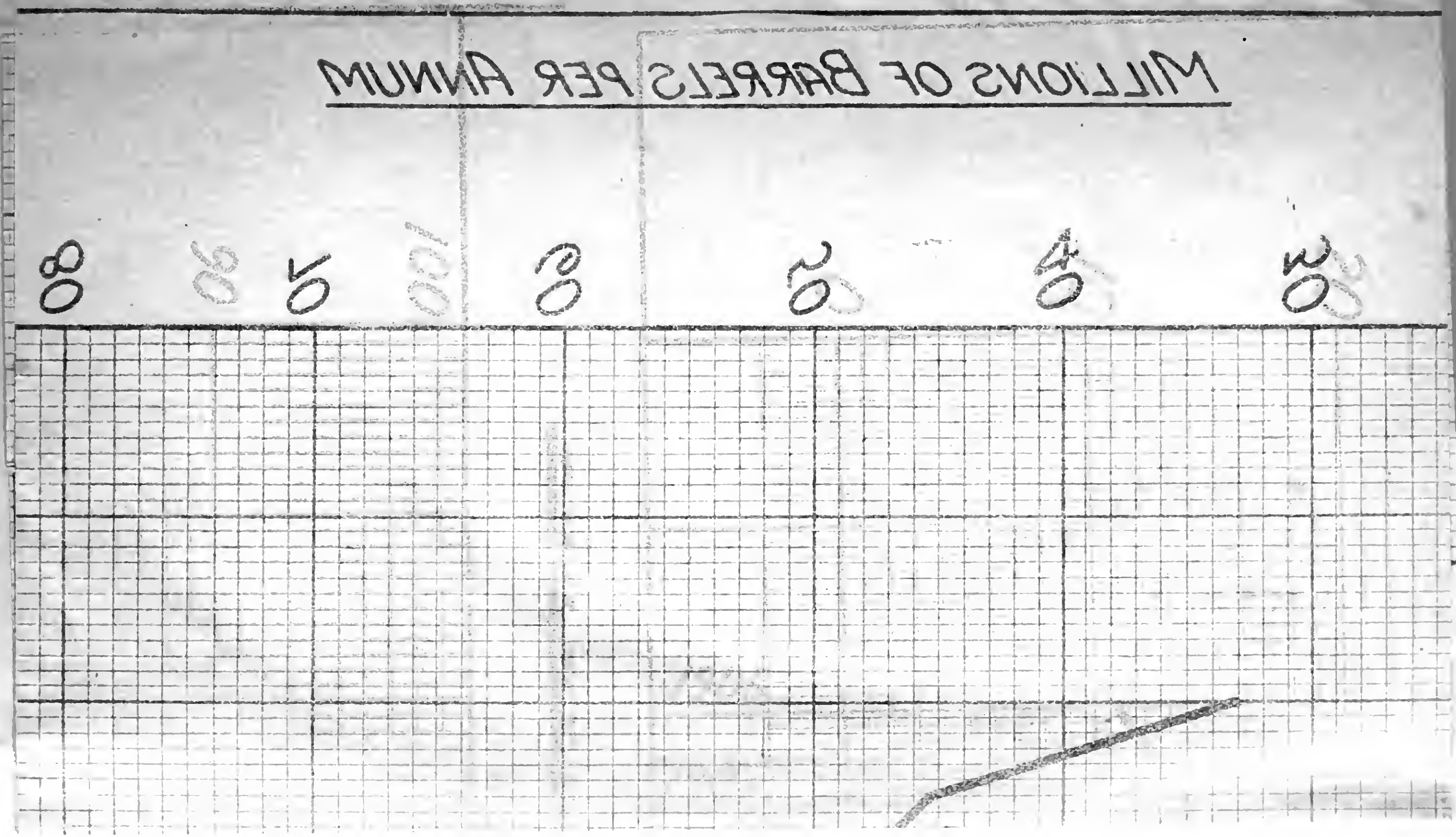

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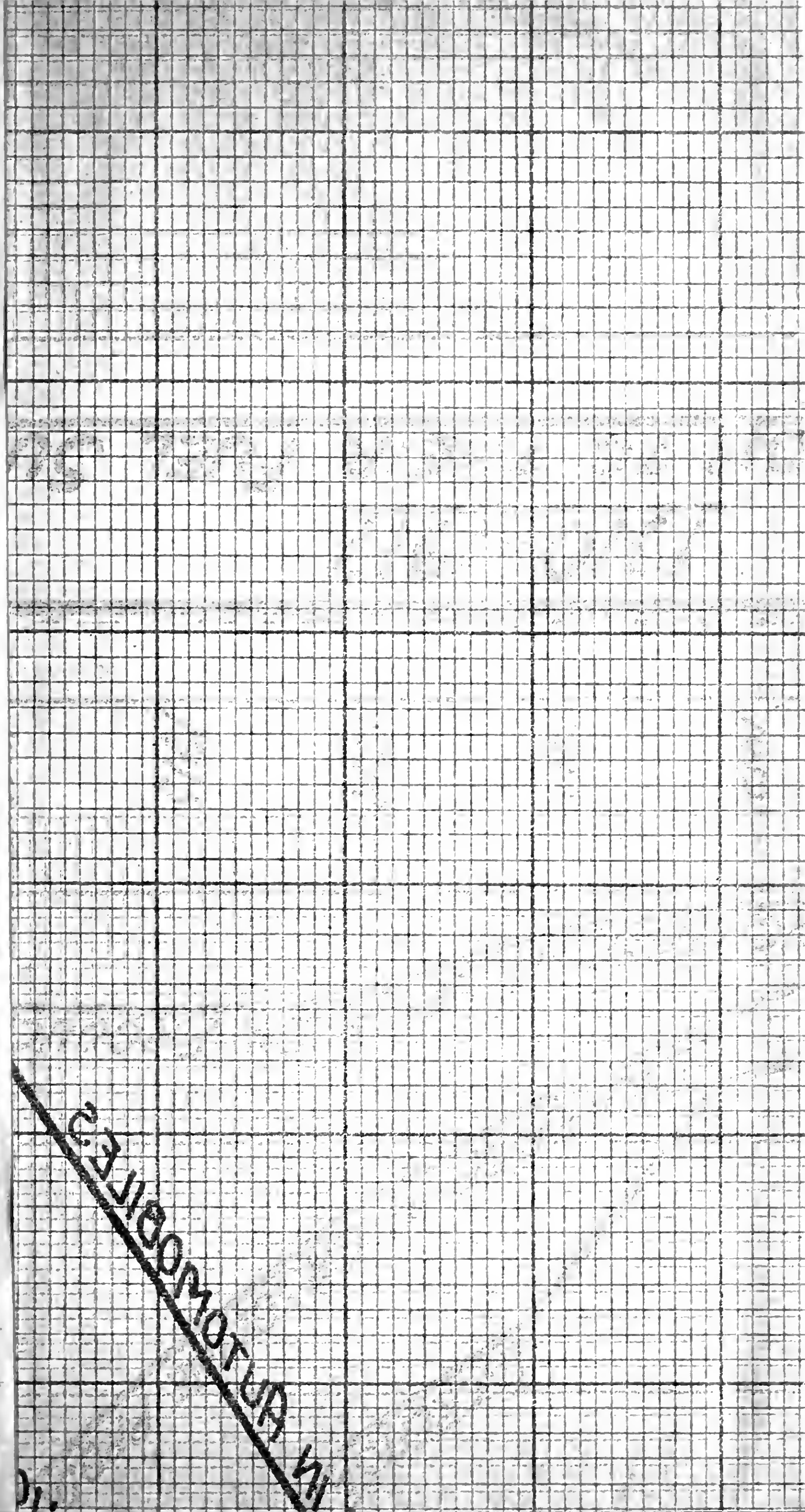

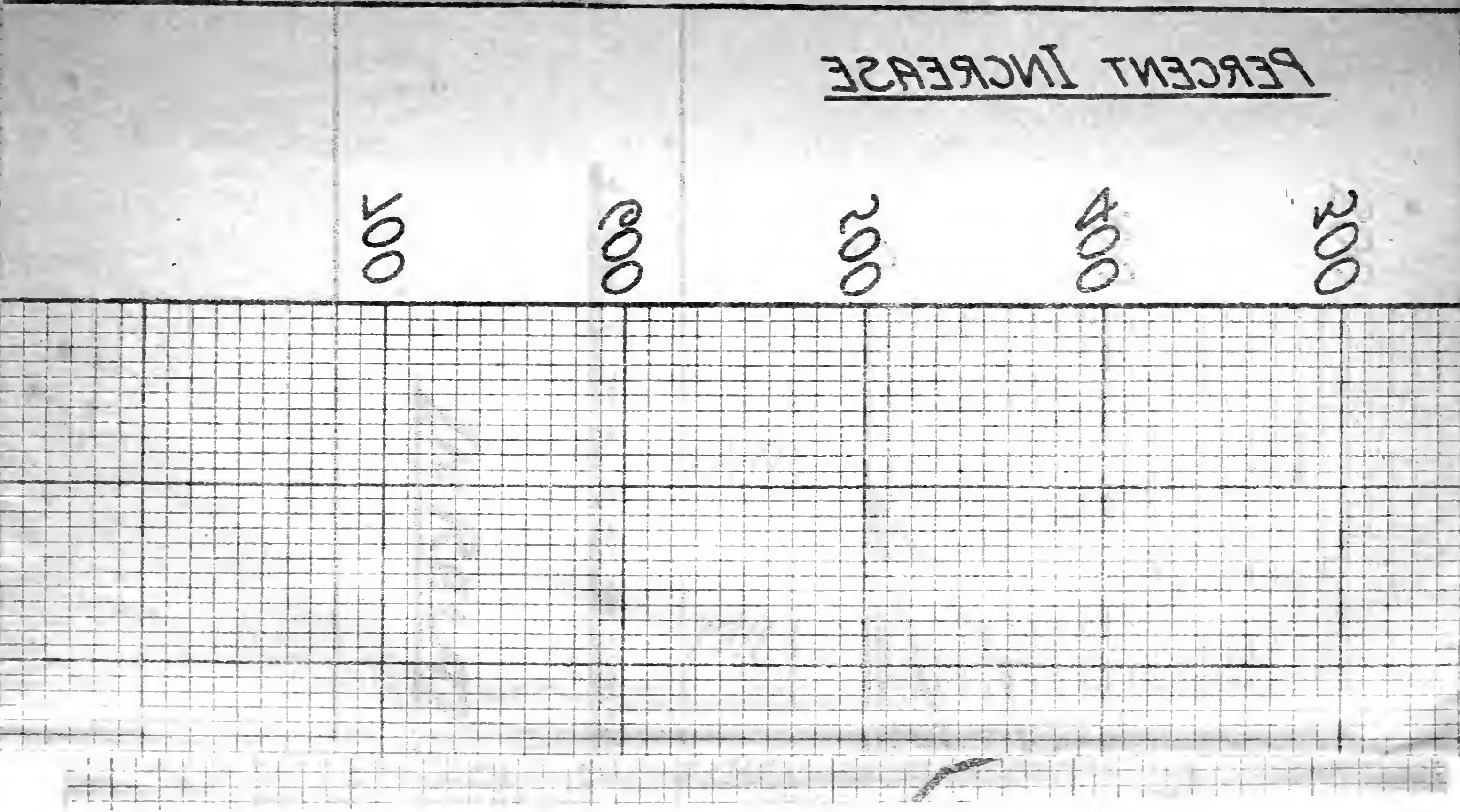
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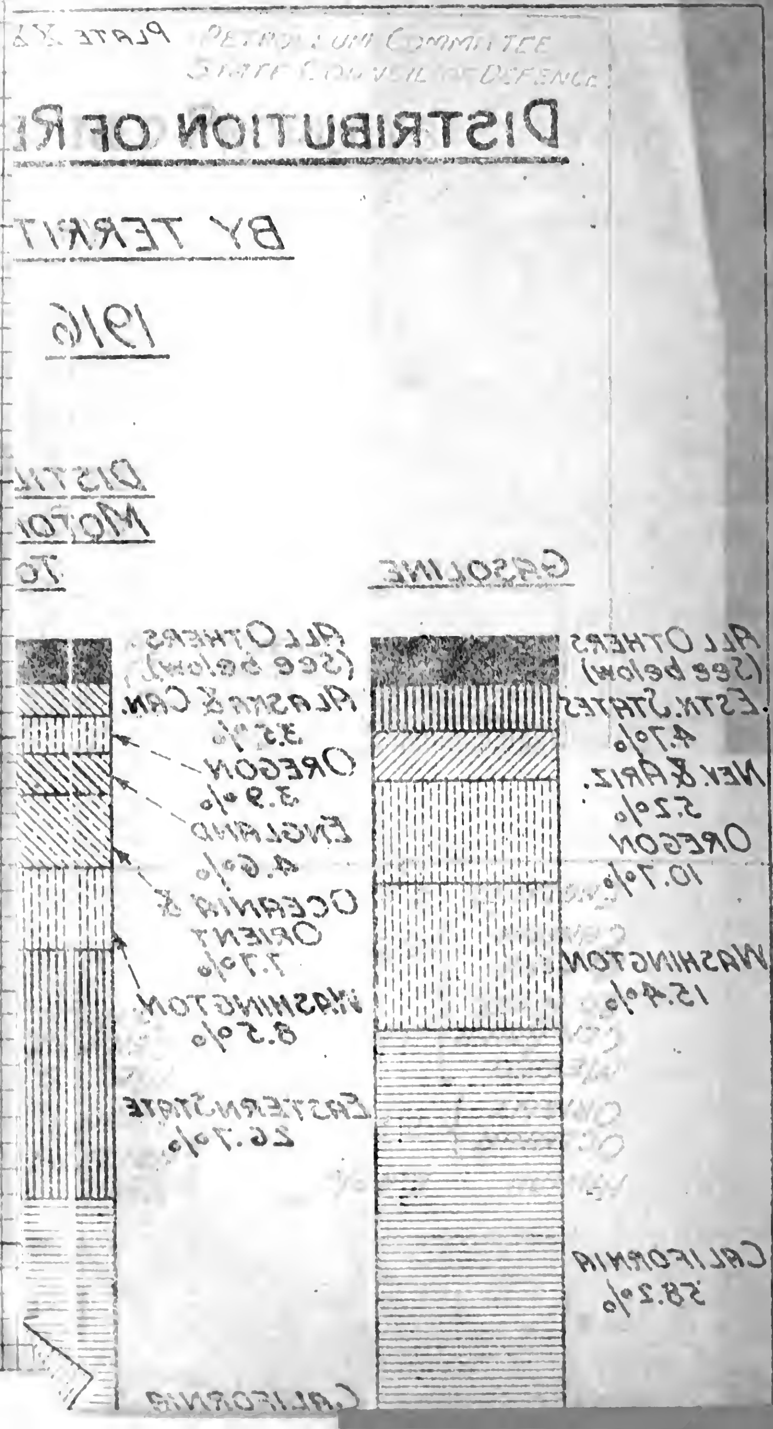
Plate XX
Petroleum Committee
State Council of Defence
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Distr
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All Others (See below)
Alaska & Can. 3.5%
Oregon 3.9%
England 4.6%
Oceania & Orient 7.7%
Washington 8.5%
Eastern State 26.7%
California
All Others (See below)
Estn. States 4.7%
Nev. & Ariz. 5.2%
Oregon 10.7%
Washington 15.4%
California 58.2%

1916		1917†		1917‡	
Crude	Refined	Crude	Refined	Crude	Refined
156,809	5,767,393	-----	4,999,992	-----	1,666,664
-----	8,595,010	-----	9,724,527	-----	3,241,509
-----	1,989,783	-----	1,727,415	-----	575,805
-----	-----	-----	-----	-----	-----
-----	16,352,186	-----	16,451,934	-----	5,483,978
-----	661,002	-----	817,125	-----	272,375
-----	772,375	-----	428,670	-----	142,890
-----	1,456,245	-----	948,033	-----	316,011
-----	-----	-----	-----	-----	-----
101,795	2,363,837	-----	2,106,036	-----	702,012
2,966,708	1,022,187	3,685,917	1,005,801	1,228,639	335,267
312,814	257,421	220,041	293,562	73,347	97,854
55,064	2,206,844	168,000	1,898,370	56,000	632,790
-----	1,185,783	-----	651,354	-----	217,118
-----	1,991,606	-----	1,621,053	-----	540,351
-----	3,689,160	-----	3,776,439	-----	1,258,813
*353	296,148	-----	122,061	-----	40,687
*560,853	94,067	*356,709	152,421	*118,903	50,807
*1,613,611	180,756	*1,157,346	260,616	*385,782	86,872
2,174,817	570,971	1,514,055	535,098	504,685	178,366
502,761	2,872,045	311,787	3,258,054	103,929	1,086,018
6,270,768	32,529,617	5,899,800	33,791,529	1,966,600	11,263,843
22,797,705	-----	22,455,837	-----	7,485,279	-----
155,793	-----	8,100	-----	2,700	-----
29,224,266	32,529,617	28,363,737	33,791,529	9,454,579	11,263,843

operation. Of the lubricants shipped to the Eastern states, a large proportion is compounded with Eastern oils.

Distillates are used as fuels for internal combustion motors, both the slow speed marine type for small vessels and the four-cylinder engine of the commercial motor truck. The increased use of Diesel and semi-Diesel engines has created a new demand for low grade distillates, and the proposal of the United States Shipping Board to use this type of motor for the equipment of their new fleet would require a great amount of this fuel.

Kerosene was once the refined product of greatest value, and still has a limited domestic market as an illuminating and stove oil.

Gas oil is in great demand for the manufacture of artificial gas, and, in spite of the improved efficiency of the gas companies, and the use of natural gas in a large portion of the state, the consumption of gas for domestic purposes has grown so rapidly that there will be great difficulty in providing a future supply of oil suitable for this purpose.

In the construction of the automobile highways of the Pacific coast, large quantities of asphalt and heavy road oil have been and are being used.

Plate XXIX shows the present distribution of the refined products of California petroleum.

VII. *Foreign Trade.*

Foreign trade, as stated above, has grown from a very desirable market for surplus of fuel or refined oils, to one which, as far as gasoline and fuel oil are concerned, is now insistent and inconvenient to the marketing companies. The exports of mineral oil from California ports now approximate 18 per cent of the total United States exports, and the growth year by year of the foreign trade is accurately reflected in the figures of the two customs districts of this state.

The effect of the great war on export conditions in the United States is strikingly shown in the accompanying table (Table 23). France, England and Italy took little oil but refined products previous to 1914, and shipments were all from our Eastern ports, where the Pennsylvania and Mid-Continent refined stocks were used. In 1914, the total to the Allies was noticeably increased, though Belgium's quota was practically completed August first of that year. The following two years saw the refined shipments to France, England and Italy steadily increase, fuel oil gaining at somewhat smaller ratio than gasoline, naphtha and benzine. In 1913, the gasoline shipments to the three countries totaled 1,400,000 barrels, and in 1916 this figure was 7,614,000 barrels, a tremendous drain on the petroleum distillate

stocks of the country. Of the lubricating oils exported, two-thirds now go to the Allies.

Exports to neutral nations of Europe have, in most cases, diminished since August, 1914, especially as to the ports within the war zone. In the Far East the use of American refined oils is so general that the heavy shipments to British India, China and Japan have continued, in spite of high costs and transportation difficulties. These countries constitute the principal market for California kerosene.

In our Western Hemisphere, the South American market has continued firm, and the nitrate and mining industries of Chile have demanded a larger share of fuel oil each year.

California's Share of Foreign Trade.

California's share of these foreign consignments is largely confined to Central and South America for fuel shipments, to England and Australia for gasoline and distillates, and to the Far East for kerosene. (See Plate XXX and Table 24.)

Practically 50 per cent of this country's oil exports to China and Japan, and 25 per cent of British India shipments are from California ports. Kerosene constitutes by far the greater portion of these oils. Shipments to China and Japan during the last twelve months (June 1, 1917) amounted to 1,850,000 barrels, four-fifths of all illuminating oil exported from the state. British India, in the same time, took some 300,000 barrels, one-tenth of the total exports.

The exports of gasoline from the two California customs districts go, in large degree, to Australia and Oceania, with the Philippines taking 10 to 15 per cent of the total.

England confines her purchases, consigned directly from California to Allied ports, to distillate, and buys approximately two-thirds of the total exported from California, while her colony, Australia, gets another 25 per cent. Lubricating oils go largely to Australia and Oceania.

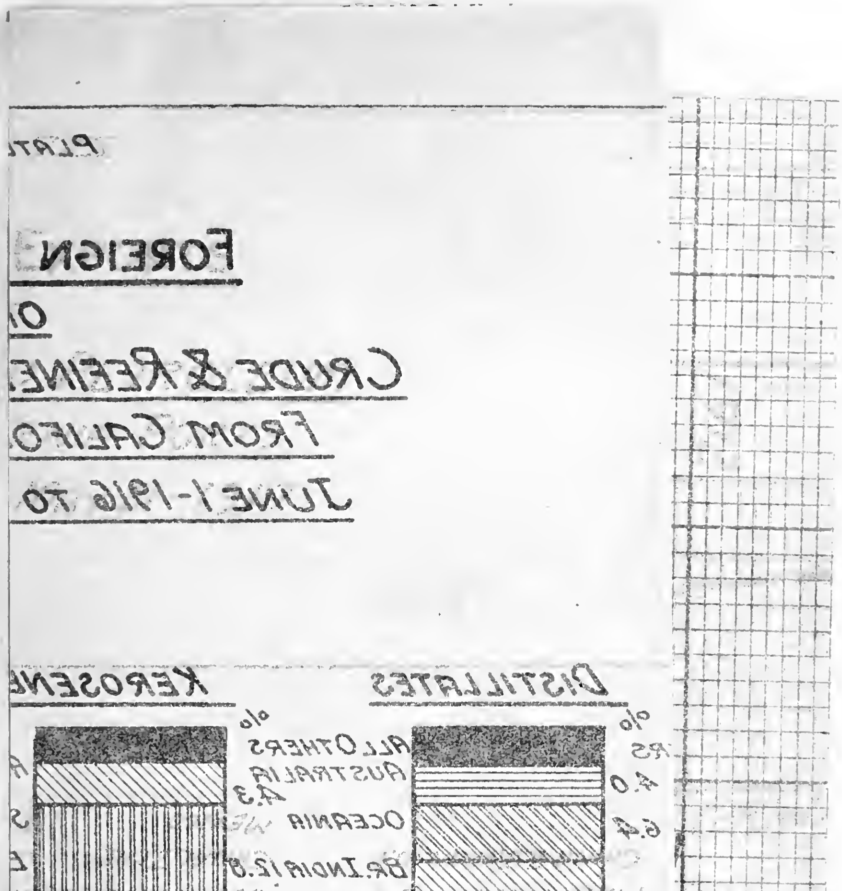
A considerable portion of the California gasoline sent through the Panama Canal to Eastern ports is reshipped to England, and is not, therefore, credited to California.

The total export of California oil, including shipments to noncon tiguous territory, has increased five-fold since 1911.

VIII. *Increased Future Demands.*

1. Industrial.

In connection with the increased export demand, the potential shor age of oil over the entire United States should be noted. In P[illegible] XXXI is given the oil export trade in the United States since [illegible]



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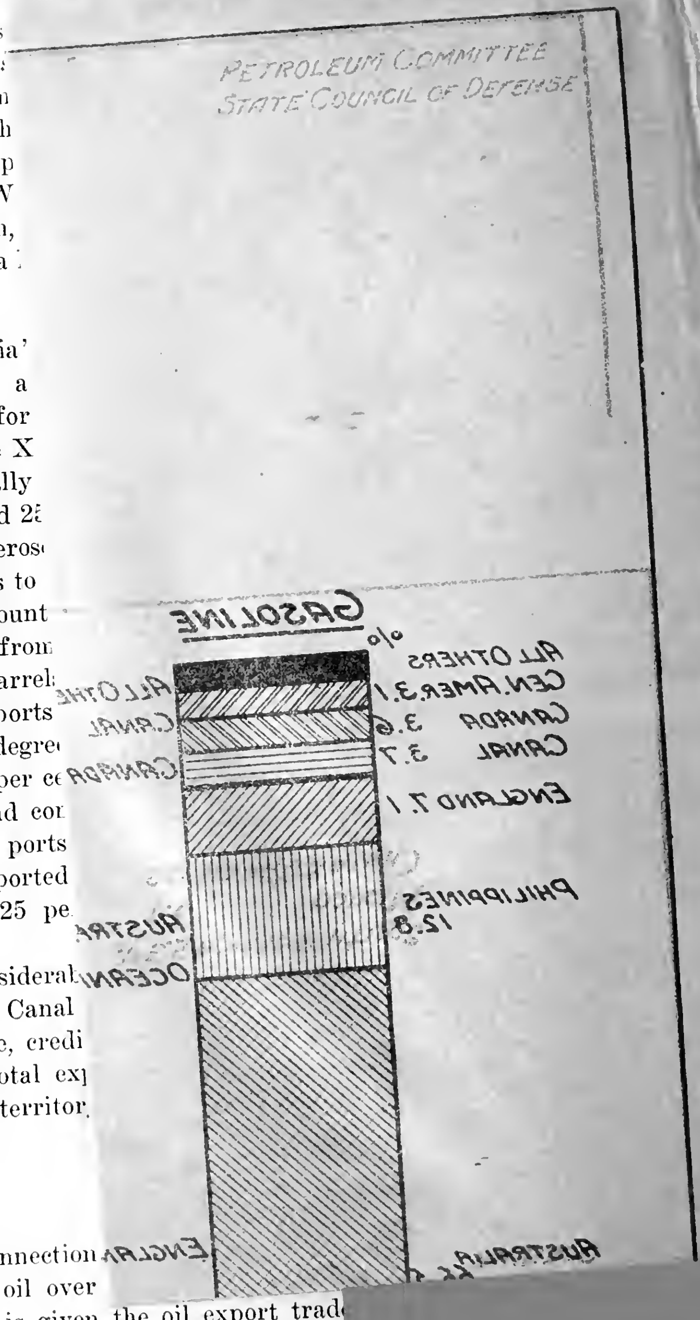

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FO]	Total
Gasoline	285,033
Distillate	382,400
Kerosene	2,343,368
Lubricati	131,716
Fuel oil a	8,085,045
Crude oil	127,660
Total	11,355,222

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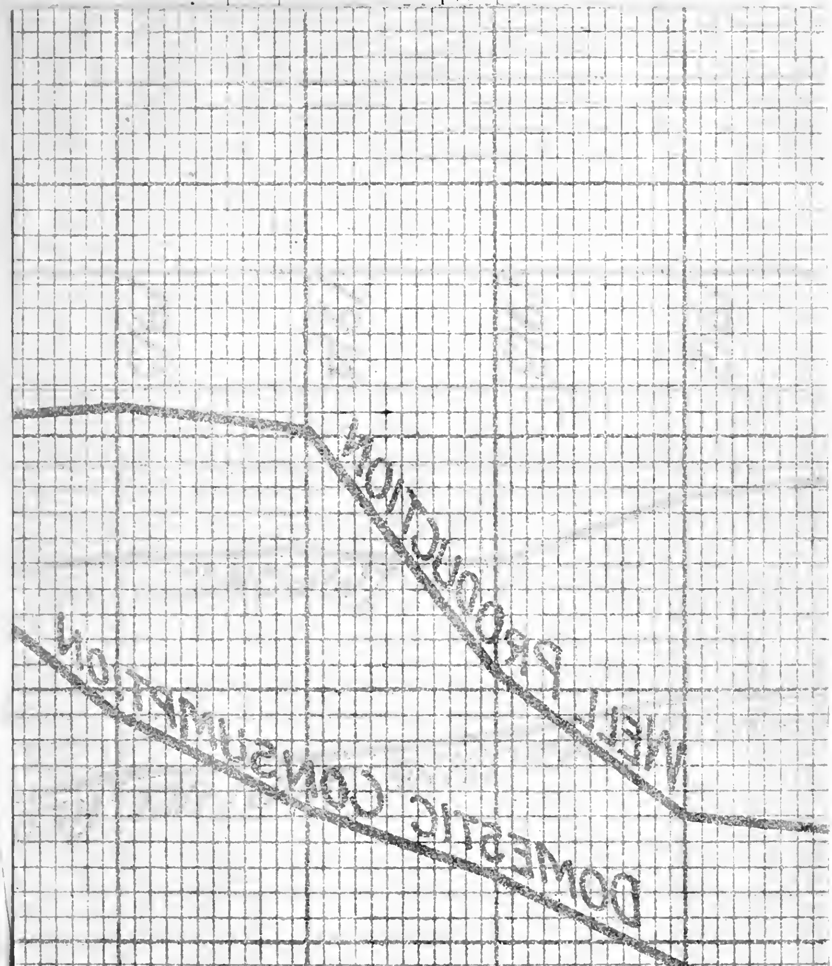

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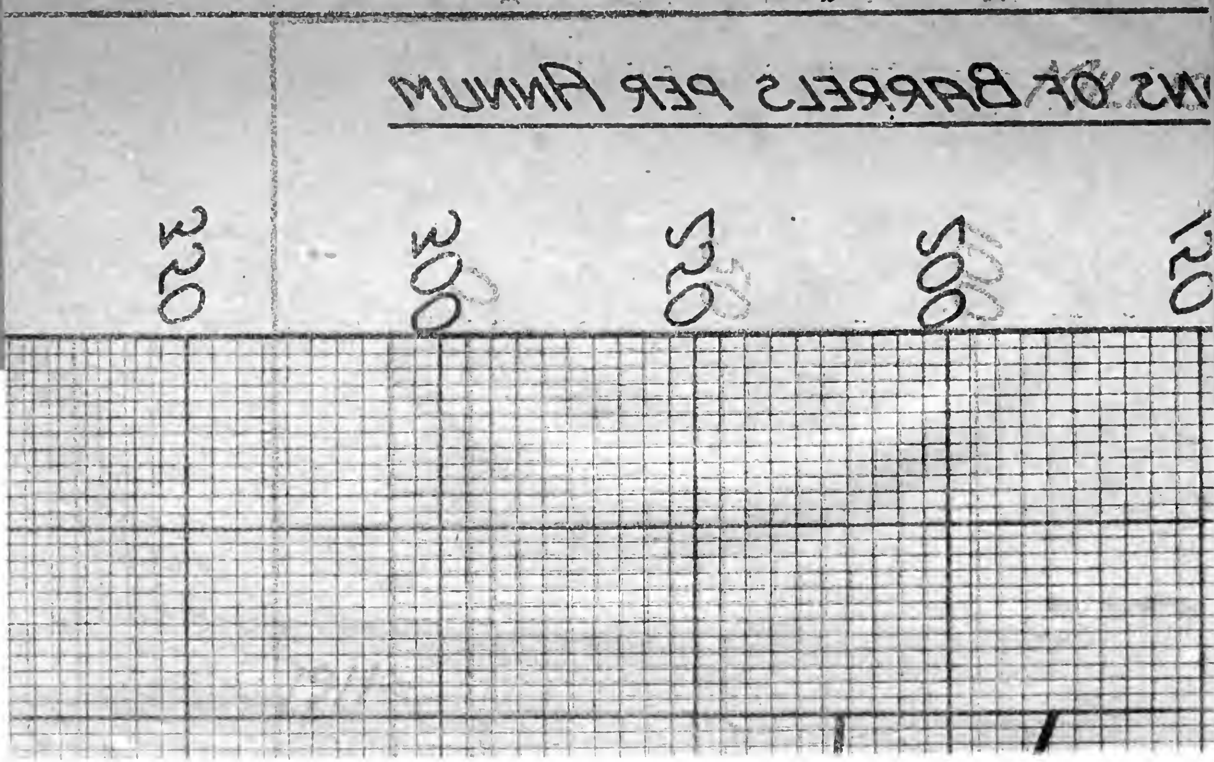
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TABLE 24.

FOREIGN EXPORTS OF CRUDE AND REFINED PETROLEUM FROM CALIFORNIA, JUNE 1, 1916, TO MAY 31, 1917.
(In barrels of 42 gallons.)

	Canada[1]	Mexico[2]	Central America	Canal Zone	South America	Australia and Oceania	Japan and China	Philippines	British India	England[3]	Total
Gasoline	10,276	1,988	8,740	10,406	6,532	189,599	582	36,369		26,541	285,033
Distillates	24,666	4,733	3,669	15,478	1,176	97,579	304	857		233,938	382,400
Kerosene		2,221	18,966	1,410	6,520	100,823	1,854,500	28,615	298,799	31,447	2,343,368
Lubricating oils	2,074	1,659	1,243	581	5,950	89,231	20,576	1,668	1,500	7,234	131,716
Fuel oil and gas oil	3,286,221	66,896	186,221	1,301,645	3,243,857	205					8,085,045
Crude oil	67,000	4,651			56,000		9				127,660
Totals for country	3,390,237	82,148	218,839	1,329,520	3,320,035	477,437	1,875,971	67,509	300,299	293,160	11,355,222

[1] Does not include reshipment from other states to Canada.
[2] Does not include shipments through Arizona.
[3] Does not include reshipments from New Jersey and New York to England.

and in Plate XXXII the relation between the growth of crude oil and refined oil shipments is shown.

The figures from which the year 1917 were estimated in Plate XXXI did not take into consideration anything more than the ordinary industrial demand. It is apparent that consumption is increasing rapidly over the entire United States, and that export shipments to the Allies must be at least maintained at the present level, while the production has reached and passed a maximum.

2. Demand Occasioned by the War.

The war demand on our own country is difficult to estimate, but one item may be taken as indicative of the importance of oil in modern warfare. If the proposed fleet of 22,000 aeroplanes should be built and transported to the European battlefront, approximately 500,000 barrels of gasoline per month would be required to keep one-quarter of these machines in air one-half the time. This is approximately one-tenth of the present total production of gasoline in the United States, and exceeds the gasoline production of California.

Within the boundaries of the United States, the problems attendant upon the movement and mobilization of troops, and the shipment of army supplies will impose a heavy service upon the railroads of the country, which will result in an increased consumption of fuel oil.

SUMMARY.

The most important facts in regard to the utilization of California oil are:

First: Fuel oil is now essential to the transportation service and industrial development of the entire Pacific coast.

Second: The development of this fuel oil market has been due to the scarcity of other fuel and the excessive production of heavy oil in the early development of the fields of the state.

Third: The refined products of California oil are widely distributed, through export and domestic shipment, and California gasoline and lubricants have been supplied to the Allies.

Fourth: This demand for these refined products is rapidly increasing, and will be accelerated by the potential oil shortage in other oil fields of the United States, and by the necessity of using California oil both for industrial and warfare purposes to offset this shortage.

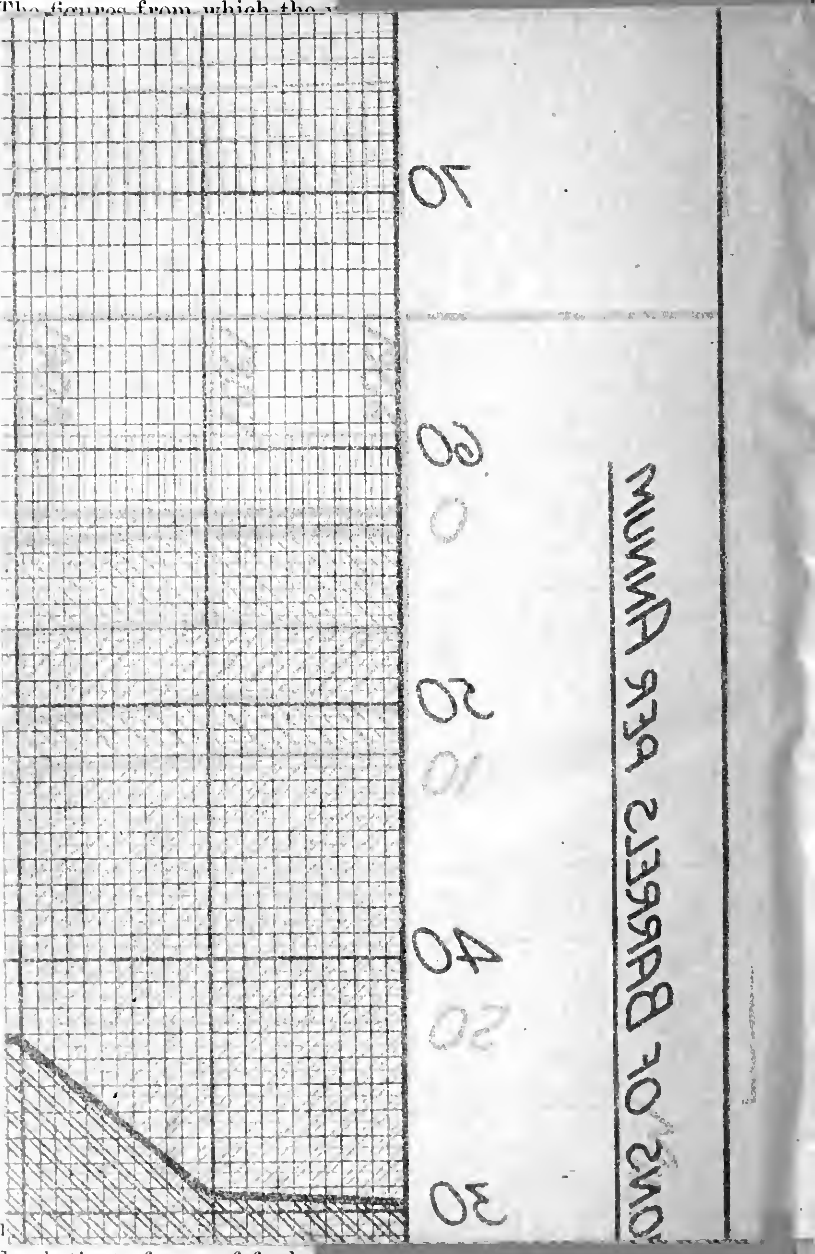
Fifth: To meet this increasing demand, California oil must be used more efficiently. Crude oil of refining quality must not be sold as fuel, and substitute forms of fuel and power must be developed as rapidly as possible.

CHAPTER IX.

Notwithstanding the most active drilling, it is doubtful whether roduction of California petroleum in 1917 will exceed the production 1916 by 2,000,000 barrels, if at all.

and in Plate XXXII the relati
refined oil shipments is shown.

The figures from which the



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CHAPTER IX.

GENERAL REVIEW.

Production and Consumption.

In this chapter we shall give a general review of the salient facts of present production and consumption of California petroleum and its products, with a reference to the outlook for the future under present tendencies of production and consumption in California and other sections of the United States.

I. *Present Production.*

As appears in Chapter IV of this report, the production of petroleum in California increased from 4,320,000 barrels in 1900 to 77,700,000 in 1910, 83,740,000 in 1911, 90,070,000 in 1912, 97,870,000 in 1913, and 103,620,000 in 1914, the year of maximum production.

In 1915 production fell sharply to 89,570,000 barrels, which production was slightly increased in 1916 to 91,820,000 barrels.

Only by the greatest activity in drilling is California petroleum production being maintained.

II. *Present Consumption.*

The consumption of California petroleum has been increasing at the rate of approximately 15 per cent annually.

In 1916 the consumption reached a total of 104,930,000 barrels, being 13,100,000 barrels in excess of production.

The effect of constantly increasing consumption has been the reduction of stocks from over 60,000,000 barrels in 1915, subsequent to the bringing in of the Midway field, to slightly in excess of 37,000,000 barrels on July 1, 1917.

III. *Anticipated Production.*

Production during the first five months of 1917 is reported by Standard Oil Company to have been 39,801,610 barrels, being an average of 263,587 barrels per day.

Although a net average of 52 producing wells was added during each month from January 1 to June 1, 1917, production during this period was barely maintained. Average daily production rose from 262,000 barrels in January to 269,000 barrels in April, but fell again to 261,000 barrels in May.

Notwithstanding the most active drilling, it is doubtful whether production of California petroleum in 1917 will exceed the production of 1916 by 2,000,000 barrels, if at all.

IV. *Anticipated Consumption.*

During the first five months of 1917 shipments of California petroleum from the fields, as reported by Standard Oil Company, amounted to 45,216,724 barrels, being 5,415,114 barrels in excess of production.

If this excess of consumption over production is maintained throughout the remaining portion of 1917, 1917 consumption will be approximately 106,000,000 barrels, or 13,100,000 barrels in excess of production.

It will be observed that this excess, which it will be necessary to take from storage, is exactly the same as the depletion of stocks in 1916, notwithstanding the fact that during the period from January 29, 1917, to June 1, 1917, over 1,100,000 barrels of fuel oil were transported by Union Oil Company from Mexico to Chili instead of being transported from California, as was the case in 1916.

The increased demand for the products of California petroleum during the last few years will be helpful in determining the anticipated increased demand for such products in 1917.

The production of lubricants by one of the California refining companies, which may be taken as typical, was two and one-half times as great in 1916 as in 1912. The production of distillates by the same company was three times as great in 1916 as in 1912, and the production of gasoline was more than three times as great.

This company's production of gasoline in 1916 increased 23 per cent over the production of 1915, while the increase in the production of lubricants was 44 per cent, and of distillates 71 per cent.

From such data as we have been able to secure we conclude that the demand for the products of California petroleum will be considerably greater in 1917 than even the large demand of 1916.

The demands on California petroleum and its products must inevitably be influenced by the conditions of production and consumption of petroleum and its products in the other sections of the United States. A concise statement of the present status of the petroleum industry in the United States with reference to production, consumption and storage is contained in letter dated May 24, 1917, from Mr. Van H. Manning, director of the Bureau of Mines, and Mr. George Otis Smith, director of the Geological Survey, to Mr. Bernard Baruch, chairman of the Committee on Raw Materials, Minerals and Metals of the Council of National Defense, which letter appears in the published testimony given on June 13, 1917, before the Committee on Public Lands of the United States Senate. We quote herewith the recapitulation of the condition of the petroleum industry of the United States as set forth in this letter.

"RECAPITULATION.

"The production for the year 1917 may be approximately 9,000,000 barrels less than it was last year. Should the Mexican supply be withheld (some 42,000,000 barrels) our total available supply would be reduced about 51,000,000 barrels.

"The demand for crude petroleum will certainly greatly exceed that for 1916. Estimates for the normal peace consumption for 1917 have been made in the following table by computing the per cent increase for each of the last two years and assuming that the normal peace consumption for 1917 will increase at the same rate.

"Table showing deliveries to the trade (consumption) during 1915 and 1916, with an estimate for normal peace consumption in 1917:

Year	Consumption (barrels)	Per cent increase	Production (barrels)	Drawn from stocks (barrels)
1914	247,015,396			
1915	276,399,918	12	281,000,000	None
1916	312,000,000	13	296,000,000	18,500,000
1917	*353,000,000	13	286,990,000	67,000,000

*Based on a normal increase of 13 per cent.

Stocks January 1, 1917	150,600,000 barrels
Depleted by 1917, normal peace demand	67,000,000 barrels
Stocks remaining December 31, 1917	83,600,000 barrels

"Attention should be drawn to the fact that the 1917 estimate in the above table is based on normal peace consumption. Figures are not available to show the increased demand due to the war or increased exports to the allies, but with the many additional uses to which gasoline will be put, such as fuel for the patrol boats, the demand for petroleum and its products will probably be larger by 20,000,000 barrels than the estimated consumption given in the above table.

"It requires no deep thought for any one to realize the seriousness of the petroleum situation, when the total reserve stocks on December 31, 1917—seven months hence—under certain conditions may not greatly exceed 50,000,000 barrels, which is only about two months' consumption.

"The situation may be summarized in round numbers as follows:

	Barrels.
Supply:	
Estimated decrease in production for 1917	9,000,000
Possible cessation of exports from Mexico	42,000,000
Total decrease	51,000,000
Demand:	
Estimated increase in normal consumption, 1917	41,000,000
Estimated increase above normal consumption due to war, 1917	20,000,000
Total increase	61,000,000
Total deficit, December 31, 1917	112,000,000
Total stocks, January 1, 1917	150,600,000
Total stocks, January 1, 1918	38,600,000

(If the supply from Mexico is not interrupted this figure will be larger.)

"These figures are, of course, based upon the assumption that refineries will be able to obtain all the crude oil they desire, which is an improbability. In fact, at the present time many refineries in the country are not running to full capacity on account of the scarcity of crude. As a large percentage of the total stocks in the country is held or controlled by a comparatively few strong companies, it is not likely that a shortage such as indicated by the above figures will exist. In fact, such a condition of affairs will be prevented by the law of supply and demand. As soon as it becomes necessary to draw upon the reserve stocks to fill the demand, the stronger companies will refuse to part with their oil and the price will rise.

"The calculations given above, which are based upon all the data of record in the Department of the Interior, show the present tendency of our supply and demand and make it of the greatest importance to take steps to meet the situation with no negative effects on the outcome of the war and with as little confusion as possible in our industrial life. Therefore, a greater production of oil is necessary."

As will be observed, Mr. Manning and Mr. Smith conclude that the total storage of petroleum in the United States will be depleted in 1917 to the extent of 70,000,000 barrels if exports from Mexico to the United States are the same as in 1916, leaving a total storage on January 1, 1918, of only 80,600,000 barrels. This storage would be sufficient to supply the estimated normal demands of 1917 for only slightly over three months.

The serious situation of the petroleum industry of the United States will undoubtedly be reflected in increased demands by other sections of the United States and by the Allies on the products of California petroleum, if not directly on California fuel oil.

The entry of the United States into war has made the situation even more critical than it otherwise would have been.

As has frequently been said, oil is the basis of conducting this war, and everything depends on it.

While we have been unable to secure data showing the exact extent to which the entry of the United States into the war will increase the demand on petroleum and its products, it seems inevitable that the battleships, destroyers, patrol boats, transports and other vessels of the navy, the motor trucks and other motor vehicles used in the transportation of men and materials for the army, the aeroplanes, and the increased requirements of industry requiring petroleum products will create a largely increased demand for petroleum and its products.

We are advised by Honorable Josephus Daniels, Secretary of the Navy, that while the requirements of the Navy for fuel oil on the west coast will not be greater in the fiscal year 1918 than in the fiscal year 1917 the total fuel oil consumption of the navy for all purposes for the

fiscal year 1918 is estimated to be from 3,000,000 to 5,000,000 barrels. this being an increase of from 1,500,000 to 3,500,000 barrels over the requirements of the fiscal year 1917.

In addition to the other military fuel requirements of the United States in time of war, the present aeroplane program calls for the construction of some 22,000 aeroplanes. If it were necessary to operate continuously this entire number of aeroplanes, the gasoline consumption would be approximately 3,800,000 barrels per month. Inasmuch as estimates as to the percentage of continuous operation which will be expected of this new branch of the Army vary from one-tenth to one-fourth of the total number of machines, it may be assumed that the actual gasoline consumption of military aeroplanes alone will be not less than 380,000 barrels per month with a possible maximum of 970,000 barrels.

Reference to the increased demand on petroleum and its products, both in California and other petroleum producing sections of the United States, caused by the war, is contained in telegram dated June 1, 1917, received by us from Mr. A. C. Bedford, chairman of the Committee on Petroleum of the National Council of Defense, reading as follows:

> "Replying to your dispatch May twenty-ninth the increased demand of United States Government and its Allies for gasoline, fuel oil and lubricating oil due to emergency created by war will be large. It is opinion of this committee that it will be difficult to promptly secure the necessary supplies and that California will naturally be drawn on to bear its proportion. At present time approximately thirteen steamers with total capacity of approximately one hundred forty thousand tons are under construction on Pacific coast and will be ready for delivery within next eight months. It is expected that these vessels will be required to deliver cargoes of gasoline and probably fuel oil and lubricants to either Atlantic coast or European ports on their initial trips which will total approximately one million barrels petroleum products to be supplied. According to estimates of Army and Navy Department there will be large increased demand over normal requirements of gasoline and fuel oil in addition to increased demand from Allies and for munition and agricultural purposes as well as a proportionate increase of lubricating oils."

V. *Necessity for Detailed Study of Possibility of Increasing Production or Decreasing Consumption.*

We conclude that, apart from the added requirements of the war, the consumption of California petroleum in 1917 will outrun production at least 13,000,000 barrels and that the demand for the products of California petroleum will be very largely augmented.

We conclude, further, that the additional requirements of the war will still further increase the deficit in the production of California

petroleum and also the demands on the products of California petroleum.

This critical situation can be met only by increased production or decreased consumption. In the following two chapters, we shall make an analysis of the possibilities of increasing production and of decreasing consumption of California petroleum so as to determine what relief can be secured from either or both these alternatives.

CHAPTER X.

FUTURE PRODUCTION—MAINTENANCE AND INCREASE.

I. *Normal Decline of Production.*

From the day it is brought in until it finally becomes unprofitable, the normal history of every oil well is a steady decline in daily yield. The rate of decline is not the same in all wells. In general, it follows a curve (see Plate XIII) which is steep in the first two or three years and gradually flattens out until it has a very low inclination in the last twenty years or more. In general, gushers and strongly flowing wells decrease at first more rapidly than pumping wells. The rate of decline is also influenced by other factors, most of which affect the rate at which the oil travels through the sand to the bottom of the well. These are discussed later.

It follows from this that in any oil field the production can be maintained at a uniform rate only by continually drilling new wells. In California, according to the district, this has been found to require from 6 to 20 per cent of new wells each year.

The decline in the production of any district is influenced also for individual years by the shutting in of wells on account of low prices and other influences, and by the idleness of part of the wells for repairs, cleaning out, and so forth.

When the productive land within a given field is all drilled up, the decline of production becomes inevitable, since all the wells are then falling off. The decline follows a tolerably regular curve which can be calculated for any extensively developed field, if adequate records have been kept. Under these circumstances the total production of a state or country can be maintained only by the opening of good new fields at sufficiently frequent intervals. It is this process that has kept the production curve of the United States rising steadily ever since 1860. When the last potential new field is fully developed, the decline in our national production will become irremediable. To speak of maintaining production or of "sustained production," therefore, involves a latent fallacy, except where dealing with a short space of time.

These statements regarding the maintenance of production apply, of course, still more forcibly to the question of increase.

II. *Estimate of Increase Required.*

1. Amount.

As explained in Chapter IV of this report, the consumption of California petroleum has been outrunning production for a year and a half at the rate of 35,000 to 40,000 barrels per day. We may, there-

fore, take the lesser figure as the minimum net increase to be supplied. Such savings in consumption as are discussed in Chapter XI of this report can hardly more than cover the further increase in consumption that will be occasioned by the war.

Owing to the normal decline in the production of existing wells, we must add to this figure a further amount equivalent to that decrease. The decline is affected by so many different factors that it varies considerably from year to year. The best estimates range from 6 to 14 per cent or higher. Mr. M. E. Lombardi has published for the year 1913–14 an estimate of 8.2 per cent for the entire state. As this agrees very closely with the best estimates we have been able to make independently, we may take 8 per cent as a conservative figure. This amounts to about 20,000 barrels per day, making the required gross increase of production, over that to be expected from the present wells, about 55,000 barrels per day, or an increase of 22 per cent over the 1916 production of the state.

It will be interesting to note that the only time such a rate of increase has been exceeded in California in the past decade was the year 1910. The preeminence of that year is to be ascribed partly to the performance of the great Lakeview gusher, which gave a net yield of about 4,000,000 barrels alone, or about one-fifth of the entire increase in California for that year.

2. Time.

We have elsewhere estimated that the margin of safety on stored oil will be reached about September, 1918. If the drilling of new wells is pushed as rapidly as it should be, the gradual increase in production which will result will tend to defer that date by perhaps six months. We may, therefore, allow about one and one-half years to reach the desired maximum increase in production.

It is not worth while to attempt a closer estimate of the time required, because there are so many things which may change the situation. However, so far as we are able to foresee, they are more likely to increase than to decrease the consumption, and this would tend to cut down the time limit.

III. *How the Increase May Be Provided Within the Time Desired.*

The production may be increased in part by better utilization of existing wells, but chiefly by drilling new ones. In so far as wells are idle for unnecessary reasons, they could be put back into service. Our investigations indicate that, with oil at present prices, nearly all of the wells in the state that can be operated are being operated. The only notable exception is that some of the wells in the Coyote Hills are being held in check temporarily because of lack of transportation facilities for the product. The production of a number of wells could be

increased by deepening them to lower and better sands, but generally it is unwise to do this until the upper sand is exhausted. There are some damaged wells which might be put into commission again through repairing, but in nearly all cases where it is profitable, these repairs are being made; and so this item likewise may be disregarded. Relief, therefore, can be secured only by the drilling of a large number of new wells.

The essential factors which appear to demand consideration in connection with the drilling of new wells are the following:

1. Materials.
2. Labor.
3. Land.
4. Transportation.
5. Operators.
6. Capital.
7. Incentive.

These have been arranged, not in order of intrinsic importance, but to suit the purposes of the following discussion. The ultimate object being the provision of petroleum and its refined products at the point of utilization, not one of the above factors can be neglected without courting failure. However, a surplus in one may in a measure counterbalance for a deficiency in another. Thus, with a larger amount of good land, less capital, materials and labor would be required.

1. Materials.

The availability of materials used in drilling, especially those which remain at the wells and hence can not be used over again, puts a more or less definite limit on the number of wells that can be drilled in a specified time. A few wells require only one string of casing, many two or three, and some as many as six. In order to economize on casing it is therefore necessary not only to choose locations where the oil sands are as near the surface as possible, but also where favorable conditions will permit the use of only one or two strings. In general, fewer strings are used where water sands are absent and conditions thoroughly known. The shortage of certain other materials also makes it obligatory to drill as few and as shallow wells as practicable. Hence every effort must be made to obtain wells of large individual yield.

Reports from three leading oil well supply houses show that the prices of materials used in oil production have risen 25 to 300 per cent above those in effect in 1914, the average being about 100 per cent. This fact alone is sufficient to indicate the existence of a serious shortage in materials in California at the present time. A similar shortage is reported from all other American oil fields. Some of the smaller oil companies report that they have already been obliged to suspend drilling operations because they are unable to obtain certain materials.

At present the supply companies are unable to deliver some of the essential kinds of material and for some they can not even place orders at manufactories for delivery in any definite, or even indefinite, time in the future. The most acute shortage seems to affect the following essential kinds of supplies:

10-inch casing.
Rotary drill stem pipe.
Tubular goods in general.
Boilers and boiler tubes.
Wire cable.
Gas engines for pumping.
Manila rope.

Some of the large oil companies have succeeded in contracting for enough material for a year or more, and a few as far as the end of 1918, but the manufacturers are unable to make the goods fast enough to keep pace with the demand. On the other hand, we are informed that the railroads are making special efforts to expedite all material destined for the oil fields. Possibly some readjustments under federal control may serve to improve the rate of delivery.

Under present war conditions, with large powers being given to the federal government to control manufacturing and traffic, and with heavy demands already made by federal bureaus for steel materials of all kinds, the oil-producing companies and supply houses are justified in fearing that even some of the supplies which are due them on contracts already made, may be diverted to other uses and particularly that the manufacturing plants will thus be prevented from making oil-well supplies, unless the interests of the petroleum industry are safeguarded by the government itself.

On account of the variation in well depths and casing requirements, in different areas, it is impossible to calculate accurately the number of wells that could be drilled with a given amount of materials. Nevertheless, using average figures, and on the basis of reports from Receiver Payne and eight of the largest companies, controlling about 80 per cent of the existing wells, we estimate that hardly more than 600 wells can be drilled with the material now on hand or definitely contracted for.

It is clear that without these materials the wells necessary for the maintenance and increase of production can not be drilled. On the whole, the shortage of material is probably much more serious than the possible shortage of labor. It is indeed one of the vital factors in the problem that confronts us.

2. Labor.

Drilling crews and other trained oil field employees are today definitely limited in numbers. Obviously the desired increase in production can be obtained most quickly by drilling the new wells as rapidly as possible so that each crew may drill more than one well in

the time fixed by the needs of the case. It takes from 15 to 90 days to drill a well 1,000 feet deep, but from 60 to 300 days to drill one 4,000 feet deep. A few wells have required one to two years. These variations among wells of the same depth are due to the fact that the rate of drilling is much slower where there are serious water troubles, beds of hard rock, or other factors that interfere with rapid work.

The active campaign of drilling which is now in progress in most of the fields in California has absorbed nearly all of the qualified men available. On the other hand, about 2½ per cent of the oil field employees of the state have entered the military service since the outbreak of the war and a further 32 per cent, approximately, have registered under the provisions of the Military Draft Law. The figures submitted to us by six of the largest oil-producing companies of the state are given in the following table and they are believed to be typical of the conditions throughout the California oil fields.

TABLE 25.

Men Employed in Field Production of Oil Who Have Volunteered and Registered.

Company	[1]Total field employees	[2]Volunteered		[2]Registered for draft	
		Number	Per cent	Number	Per cent
A	893	33	3.7	390	44
B	582	12	2	232	40
C	2,045	90	4.4	750	36.5
D	441	17	3.9	160	36.3
E	541	25	4.6	125	23.1
F	[3]2,498	?	?	[3]628	25
Totals	7,000			2,285	32.6

[1]On April 1, 1917.
[2]June 25, 1917.
[3]Includes also men employed in refineries, along pipe lines, etc.

Of the total number of men employed in the producing part of the oil business, 85 to 90 per cent are classed as skilled operatives. Among these are drillers, tool-dressers, pumpmen, machinists, engineers, gagers, foremen, geologists, superintendents and others. On the average it takes more than one year for any of these men to acquire the necessary skill and experience in their work. The value of an able and experienced drilling crew and their supervisors is evident to anyone who will take the trouble to review the hundreds of cases where wells have been spoiled through bad judgment or preventable accidents, or in which the oil sand has been injured or ineffectually tapped. Many of the unskilled laborers are also absolutely necessary to the conduct of the industry, in view of the heavy work required in many of the operations. To some extent, such men as carpenters, clerks, stenographers, boarding

house employees, and some others, could be replaced without much difficulty, but the rest, particularly those in positions of responsibility, can ill be spared.

Reports submitted to us indicate that about 370 drilling crews were actively at work in California in June, 1917. They are completing over 60 wells per month, or between 700 and 800 per year. The location of this drilling activity is shown on Plate XXXX. These crews are drilling on various kinds of land in all the oil fields of the state. If they could all be transferred to those lands where drilling is relatively easy and the depth not great, they could nearly double the number of wells finished per year. As shown on Plate XXXIV, the number of wells that will be required to meet the present emergency depends chiefly on the productivity of those wells. If they are not better than the present average for the state, it would require over 1,500 new wells, or about as many as the present drilling crews could be expected to finish in a year and a half, even under the most favorable circumstances. If, however, the new wells are as good as those that were brought in in May (expected to average nearly 110 barrels per day for the first year) the available drilling crews would be easily able to put down more than the number required. If, as the committee recommends, only the better lands are used, then it would seem that the labor shortage is not imminent, even if a reasonable proportion of the men should be taken for the military service. But the proviso must not be overlooked.

Giving due regard to the probable circumstances, we conclude that the removal of any large number of the oil field employees from their present occupations would seriously injure the work of increasing the oil supply by drilling many new wells. In that event, it would seem that the only solution of the difficulty would be some sort of government control of the industry, making it possible to use the remaining drilling crews and other skilled laborers only on the most favorable and productive lands without regard to the present plans of operators in other parts of the state. This would give the largest production of oil per unit of labor expended.

3. Land.

a. WHY THE MOST FAVORABLE LANDS ARE REQUIRED.

It has already been shown that, as an abstract proposition, the best lands to be drilled are those which will give the largest yield per well, with the least expenditure of labor and material, in the shortest space of time. The accompanying diagram (Plate XXXIII) shows which of the California fields have the highest average production per well. Plate XXXIV indicates that the required increase in production would require an extraordinary number of wells if they were all drilled on poor land, or, in other words, that the number of wells which practically can be

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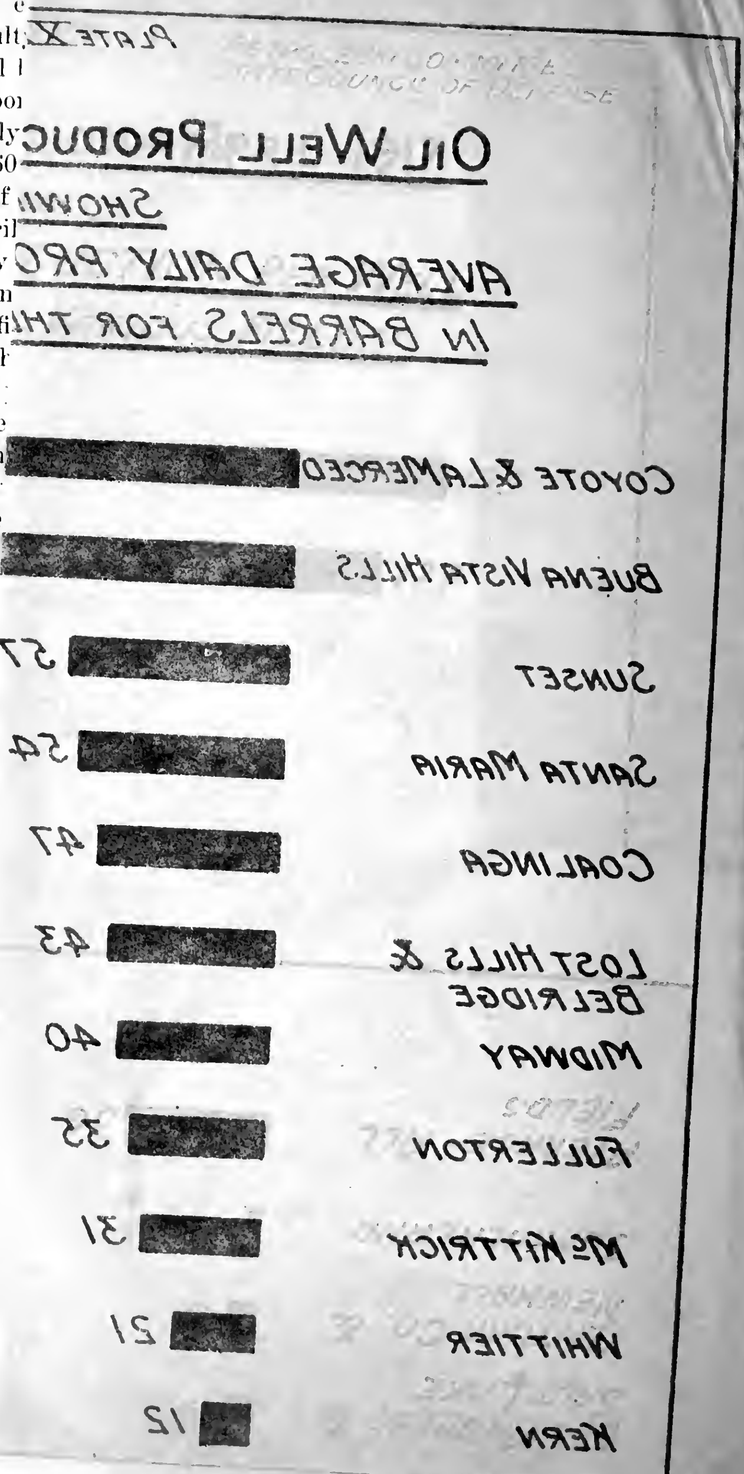

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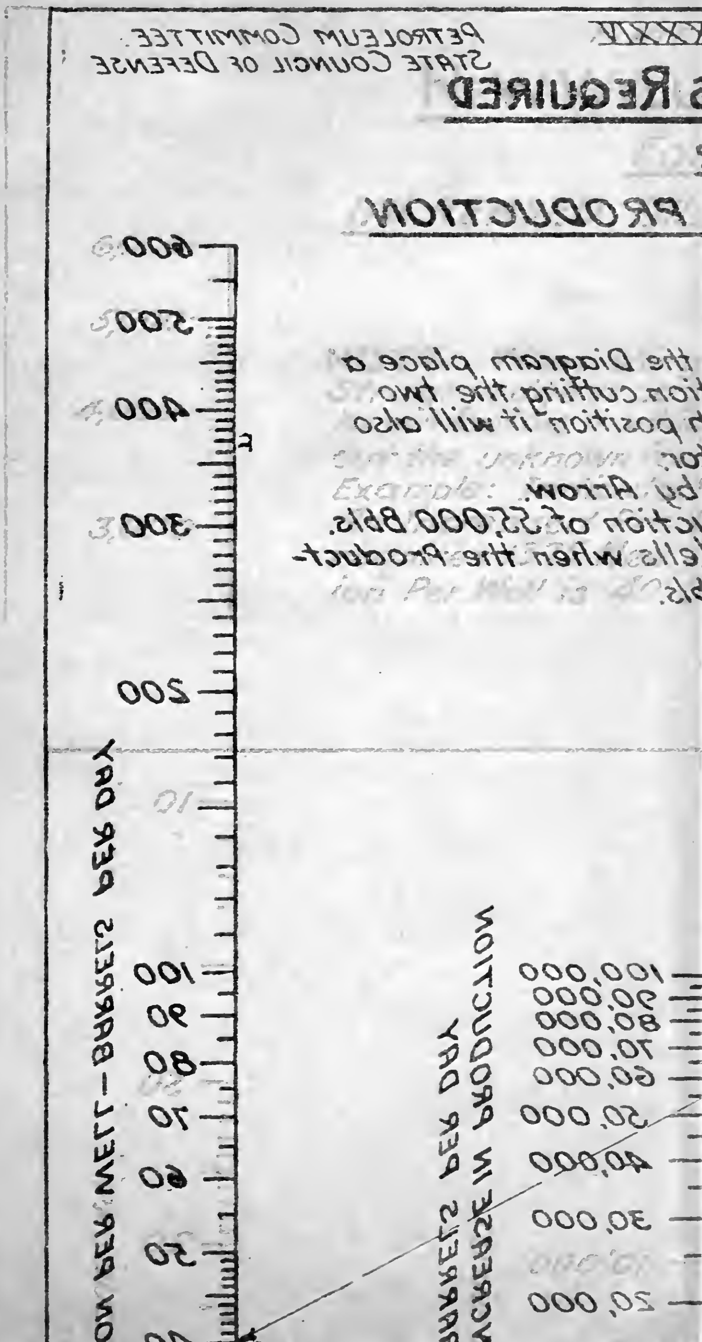

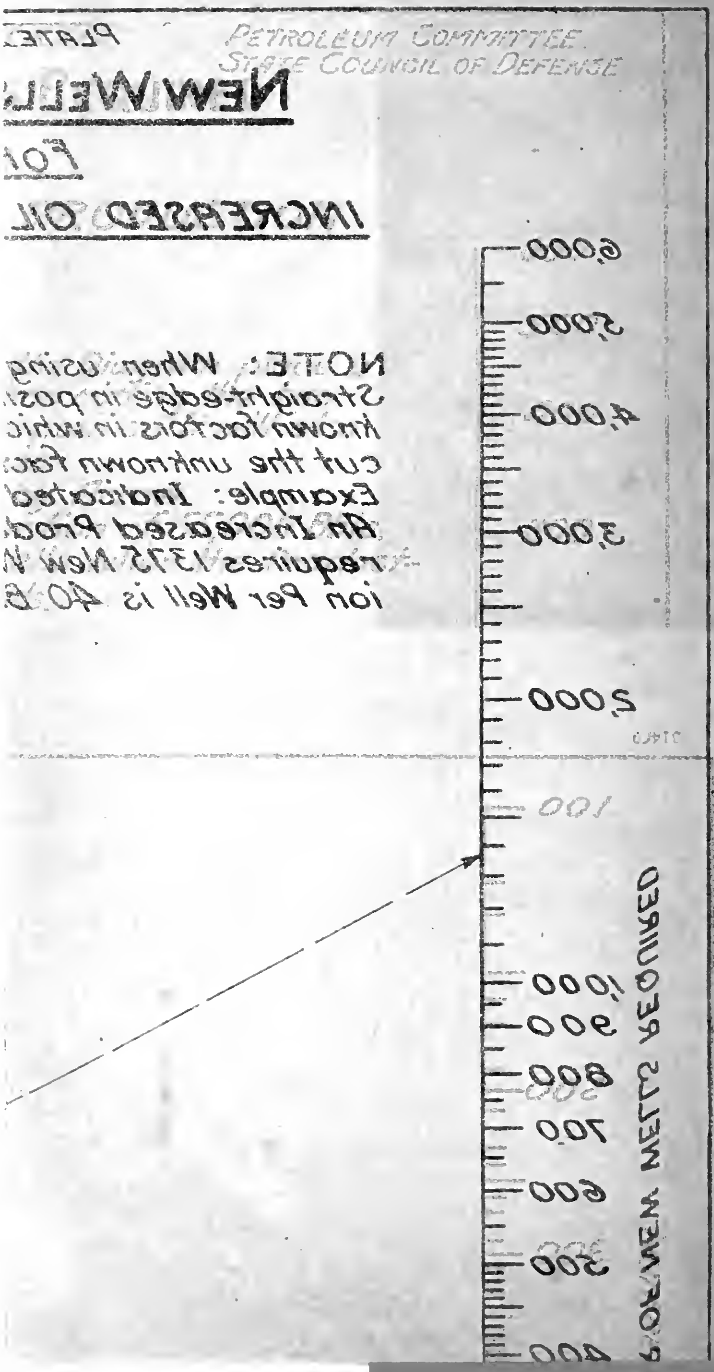
PETROLEUM COMMITTEE
STATE COUNCIL OF DEFENSE

drilled within 12 to 18 months can give the requisite increase only if the land yields more than about 70 barrels per well per day. The diagram (Plate XXXV) also shows the average depth of wells in the better fields. Depth is an important consideration, not only because it determines in part the amount of casing to be used, but because the rate of drilling at great depths is much slower than near the surface (see Plate XXXVI).

We are not in a position to predict whether it will be more difficult to get access to the best lands or to obtain the necessary supplies and material. If the latter is true then the drilling of the best land becomes essential to success. From all the data at our command we believe that the release of the lands is possible, but the sufficient increase of material nearly impossible.

b. LOCATION OF MOST FAVORABLE LANDS.

So far as time permitted, we have made a careful study of the productivity and other characteristics of the various oil fields in the state. As a result we find that by far the largest part of the territory is so poor that it could not provide a large increase in production without an enormous expenditure of material and labor. We have therefore limited our consideration in this instance to ten tracts, which appear to include nearly all of the better lands available in the state. In this connection we have taken account not only of the daily production to be expected from new wells, but also the amount of material required per well, the length of time in drilling, the likelihood of water trouble and other special difficulties, the gas pressure and other factors involved.

There is great diversity among oil fields in the matter of the productivity of their wells. In some, the average yield is less than one barrel per day, while in others it may amount to tens of thousands of barrels per day. For the California fields these facts are shown in the diagram (Plate XIV). As a rule, wells which must be pumped rarely give 500 barrels per day; and the average for such wells, in the state of California, is less than 30 barrels per day. By far the most productive fields are those which contain strongly flowing or "gusher" wells. Thus the famous "Corona No. 5" gusher near Panuco, Mexico, produced oil for several months at a rate greater than all of the wells (over 1,400) in the most productive of the California fields (the Midway field) combined. The "Lakeview" gusher in the Sunset field had an initial production per day almost equal to the present yield of the entire Coalinga district with its 900 or more wells. Gushers and flowing wells in general, being due to gas pressure, are characteristic of the early life of certain fields or parts of fields, but are entirely absent from other fields. On land where several wells have already been drilled, it is therefore not difficult to predict whether succeeding wells in the same

vicinity are likely to flow freely or will require pumping. Of course exceptions occur.

Evidently a large increase in production is best obtained by drilling on land that has been proved to be gusher, or at least flowing well, territory.

All the data at our command indicate that the Buena Vista Hills (in the Midway field) include the best of the proven territory in the state. The wells are of moderate depth, drilling is comparatively easy, and wells can be finished in from sixty to ninety days. Since the gas pressure is still compartively high in a large part of the field, there are many flowing wells, whereas most wells in other districts must be pumped.

The Coyote Hills and La Merced fields, east of Los Angeles, equal or exceed the Buena Vista Hills in average daily productivity of the wells. They are, however, less favorable for several reasons. There is but little gas in the La Merced field, and after the first fews days the wells have to be pumped. Even in the Coyote Hills field hardly more than half the wells flow. Furthermore, in the Coyote Hills the wells average more than a thousand feet deeper than in the Buena Vista Hills, and in the La Merced tract only a fraction of one square mile has been proven to be productive. Both fields are greatly handicapped at present by insufficiency of railroad and steamer transportation for their products. Nevertheless, these are easily the second best fields in the state and are probably the only ones to rival the Buena Vista Hills.

In the Sunset field there is an area of something more than two square miles forming part of the so-called "Sunset Flat," in which many of the wells are fair producers and some of them flow. In previous years several strong gushers have given prominence to this part of the field. Although part of this tract is already thoroughly drilled, there is much land still vacant. Drilling on these lands is certain to provide wells which will pump two to four hundred barrels a day and there is a fair chance that some of them will flow. In this locality there are several oil sands, and many of the poorer wells have reached only the upper beds. The lower sands in most parts of the tract give much larger yields. A serious handicap in this field is the deficiency of water supply for drilling any more wells at a time than are now being drilled.

In the East Side field of the Coalinga district there are undrilled lands of much larger extent and on the whole rather higher productivity. On the average, however, the wells are somewhat deeper. Some of them flow—a few of them vigorously—and others require mere agitation by the pump. Operations in this field are at times seriously hampered and curtailed by the difficulty of obtaining water for the drilling operations. In certain localities water has invaded the sands and is not yet under

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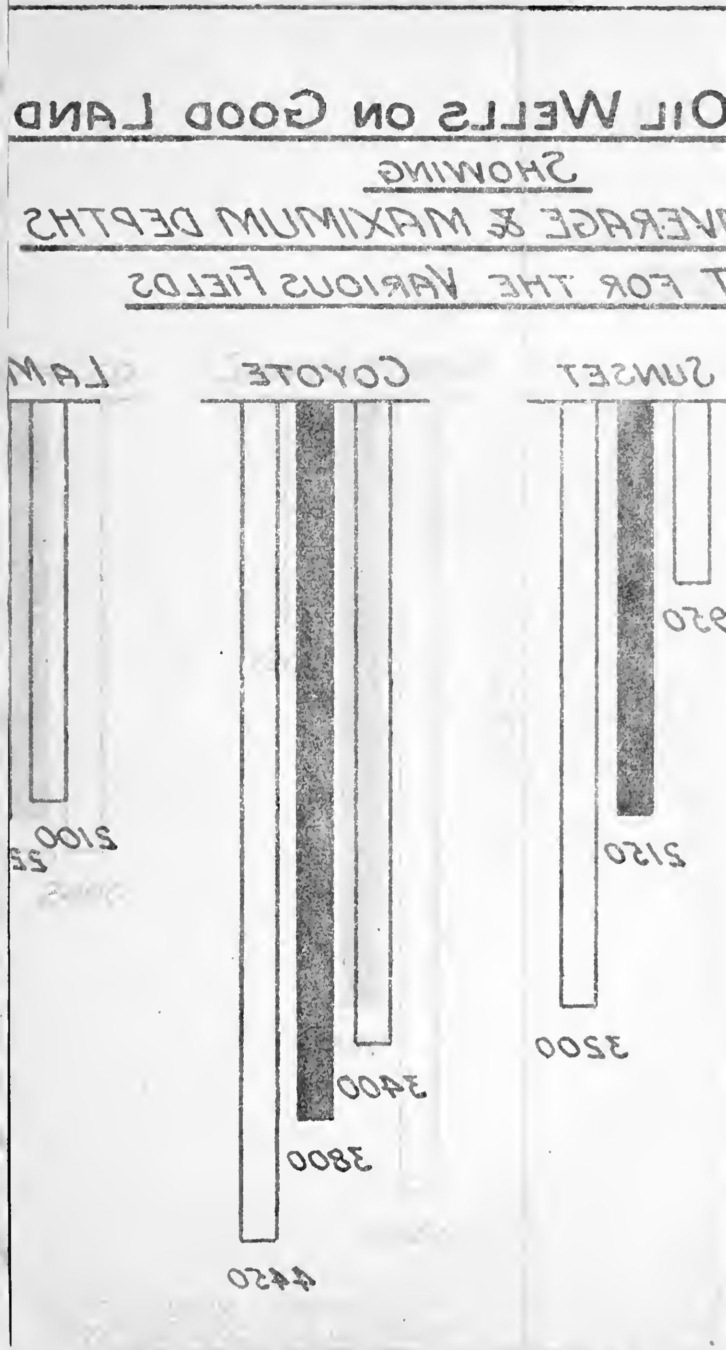

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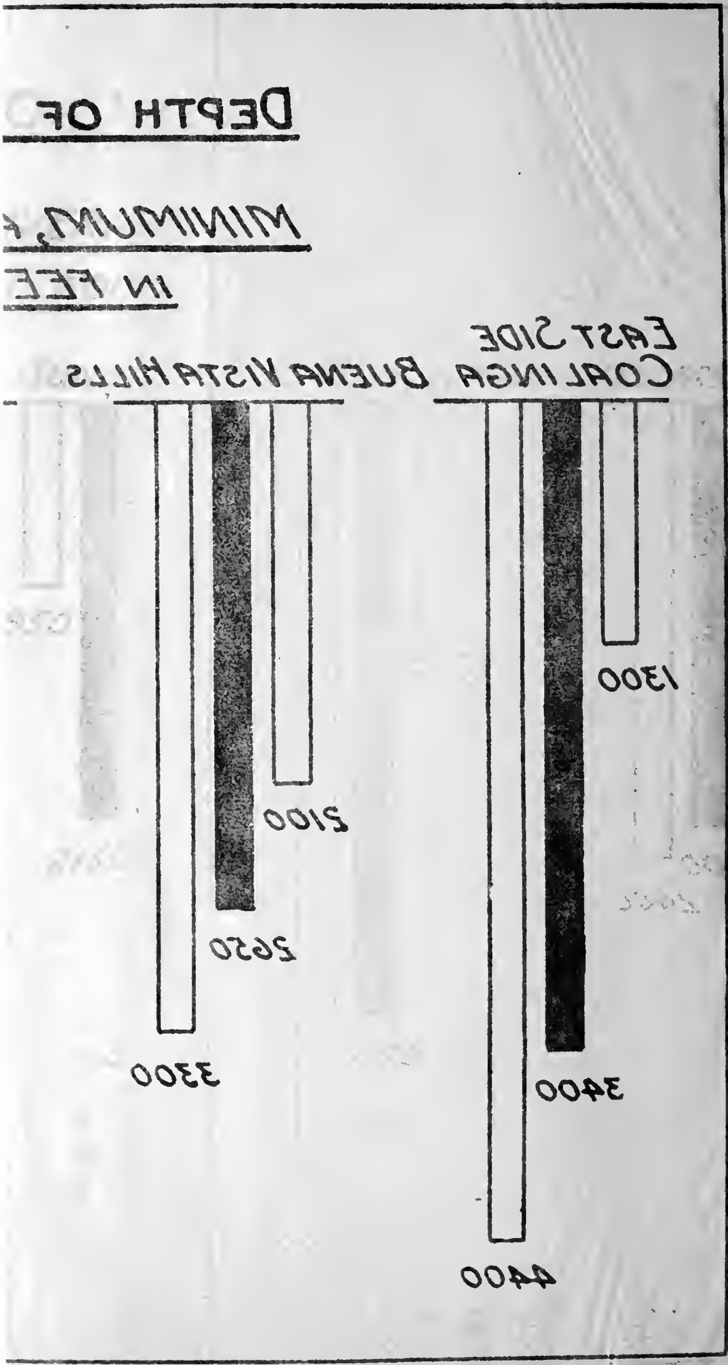

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control. In one section choking of the wells by paraffine adds a difficulty rare in California fields. On the whole, it is a field full of perplexities for the drilling manager and demands the highest skill and intelligence for continuous success. As in the Sunset Flat, here there are several oil sands, and in many places it is bad policy to drill on into the lower and more prolific sands before exhausting the poorer but still productive upper zone. So far as casing is concerned this field requires, under skilled management, less than the average, although not all the operators are as economical as they might be.

Near the head of the Coalinga syncline there is a small area worth considering. One of the wells has given as much as 700 barrels per day. On one side, however, the oil sand has been invaded by water. In any event only a few good wells could be drilled here.

There is another tract of perhaps 400 acres just northwest of the town of Coalinga, in the West Side field. In general, it is about on a par with the average of the East Side field, although perhaps a little less prolific. No flowing wells are to be expected.

In the Santa Maria district, including the Casmalia, Santa Maria and Cat Canyon fields, there are areas in which the individual wells are about as good as those in the last two or three fields mentioned. Practically all of them have to be pumped, but the better wells yield from 150 to 700 barrels per day. While a few of the wells are less than 2,000 feet deep, most of them are much deeper (3,000 to 4,000 feet) and the operators are using more casing than in most other fields in the state—five or even six strings in many cases. Some parts of the fields (Casmalia) are badly involved in water troubles. Owing to uncertain and variable conditions, prospecting is slow and is attended by much difficulty. Furthermore, much of oil in the Casmalia field is so heavy (heavier than water) and viscous that it can not be pumped through the pipe lines until it has first been mixed with lighter distillates to render it more fluid; and the available quantity of such distillates is now insufficient to take care of more than 6,000–7,000 barrels per day. Added to this is the further difficulty that the product is almost solely dependent upon steamer transportation to reach the market. This fact alone may disqualify the entire district, so far as the war emergency is concerned.

In addition to the fields which have already been described, there are very small parcels of undrilled land in the Belridge and Whittier fields, and perhaps in the Lost Hills field, in each of which one or more wells might be drilled with a reasonable expectation of getting results at least as good as in some of the other preferred lands. In most cases, however, there is considerable uncertainty, and altogether the undrilled acreage is so small that we have felt justified in omitting it from our calculations.

The fact has been stated above that the production of the state can be maintained for more than a few years only by the development of entirely new fields. We have therefore inquired into the question of finding such new territory. Geological conditions more or less favorable to the existence of oil deposits have been found in the Elk Hills (Naval Reserve No. 1), in the Kettleman Hills (Fresno and Kings counties), in the vicinity of San Diego, and in some other parts of the state. None of these areas have, however, produced oil in commercial quantities, although wells have been drilled in all of them. They must still be regarded therefore as lands of unknown possibilities. California, in general, has been so thoroughly prospected for oil in the last few years that the best informed geologists entertain but little hope of discovering large new fields.

In view of the present scarcity of drilling materials and the urgent necessity of getting an immediate increase, it would seem that the exploration of these areas should be postponed until conditions are more nearly normal in this country.

c. AVAILABILITY OF THE BEST LANDS.

The preceding pages deal largely with facts, but we now come to several subjects which are involved in much uncertainty.

As already explained in Chapter III, a large part of the best oil lands in the state are now withheld from development by federal suits. The map (Plate VII) shows the exact number and distribution of these lands now wholly or partly unavailable. It will be seen that these include nearly all the lands in the Buena Vista Hills and the Sunset field, and about half of those in the Coalinga district. Yet these are almost the only lands in the San Joaquin Valley which are capable of yielding a large increase in production. It is our unqualified opinion that until these lands are in some way opened to rapid drilling, and for several months thereafter, a great increase in oil production can not be obtained from the valley fields. Table 26 shows separately the estimated undrilled acreage of the immediately available, as compared with the withdrawn lands in the five best districts.

If we are right in estimating that approximately 57 per cent of the acreage and 74 per cent of the well locations on these lands will be unavailable for drilling until some kind of decisive action is taken by the courts or the federal government, then the estimates of possible increase in production, which are given in Table 27, must be reduced accordingly. Such a reduction brings the figures for that gross increase far below the estimated minimum requirement of 55,000 barrels per day.

d. CONDITIONS IN NAVAL RESERVE NO. 2.

Although the committee is reluctant to enter into any discussion of this subject, in view of the present controversy regarding it, we feel

TABLE 26.

Classification of Preferred Oil Lands in California, According to Their Present Legal Status.

Status	Naval Reserve No. 2				Coalinga			Sunset				Coyote-Mereed— Not in suit	Santa Maria, etc.— Not in suit	Totals
	K. T. & O. suits	Other suits	Not in suit	Totals	K. T. & O. suits	Not in suit	Totals	K. T. & O. suits	Other suits	Not in suit	Totals			
Acres—														
Number	4,690	2,470	2,080	9,240	2,260	3,260	5,520	700	410	230	1,340	500	1,870	18,470
Per cent	51	27	22	100	41	59	100	52	31	17	100	100	100	
Well locations—														
Number	414	223	14	651	161	136	297	80	25	17	122	50	93	1,213
Per cent	64	34	2	100	54	46	100	66	20	14	100	100	100	

Recapitulation for the State.

Legal Status.

	Number	Per cent
K. T. & O. suits—		
Acres	7,650	41
Well locations	655	54
Other suits—		
Acres	2,880	16
Well locations	248	20
Not in suit—		
Acres	7,940	43
Well locations	310	26

Fields

	Acres (per cent)	Locations (per cent)
Valley fields—		
In suit	65	62
Not in suit	35	38
South and coast fields—		
In suit	0	0
Not in suit	100	100

NOTE.—Acreage is estimated within boundaries of preferred tracts whether drilled or undrilled. Well locations are estimated from spaces on these lands still vacant and according to the usual spacing plans.

TABLE 27.

Possible Increase in Daily Yield (in Barrels) from California Fields Within One and One-half Years.

Field	Naval Reserve No. 2			Other valley fields			South and coast fields		
	Class A	Class B	Class C	Class A	Class B	Class C	Class A	Class B	Class C
Coalinga East				1,000	11,300				
Coalinga Syncline					5,400				
Coalinga West					1,500	1,600			
Buena Vista Hills	50,000	31 000	15,000						
Sunset Flat				2,500	3,900	7,500			
Coyote Hills							5,500	4,000	400
La Merced							3,400		
Casmalia							2,000		
Santa Maria								3,000	1,300
Cat Canyon							2,800	9,000	1,200
All others						500			200
Totals	50,000	[illegible]	15,000	3,500	22,100	9,600	13,700	16,000	3,100

Distribution According to Legal Status.

Status and claass	Barrels	Per cent
Lands not in suit—		
A	20,500	30
B	30,800	45
C	3,600	15
Lands in sult—		
A	47,700	70
B	38,300	55
C	20,600	85

Total, b[illegible]ses, in the State.

	Barrels
A	67,200
B	69,100
C	27,700

Summary

Class	Valley fields		South and coast, all
	Naval Res. 2	Outside	
A	50,000	3,500	13,700
B	31,000	22,100	16,000
C	15,000	9,600	3,100
Totals	96,000	35,200	32,800
Grand total			164,000

NOTE.—These figures apply only to the preferred lands and are based on assumptions explained in the text.

compelled to do so, because it is vital to the problem now facing us. We do not, however, attempt to discuss the questions of policy and justice that have been raised by others.

Petroleum in the ground differs from coal and other mineral deposits in being mobile. It migrates underground in response to pressure and always in the direction of least pressure. The pressure is either hydrostatic, or is due to the expansive force of compressed gas, which may be dissolved in the oil, or separate from it, or both. The ability of the liquid to migrate in response to pressure depends chiefly on its own viscosity and the porosity of the rock through which it moves.

In general, heavy oils (10° Baume) are so tar-like that they migrate very little unless the temperature is high; whereas, light oils (30° to 55° Baume) pass through rock as readily as water, or more so. The oils of the ten fields which have been selected for special consideration in this instance vary from 10° to 35° Baume, with an average of about 23° Baume, and are, therefore, mostly intermediate as regards their viscosity.

The rocks inclosing the oil in the California districts vary from clays, in which the pores are so small that liquids are held in them almost without movement, through sands of various degrees of coarseness, up to gravel beds and brittle rocks which have been fractured and, therefore, contain many cracks that serve as avenues of movement. The actual production of oil is almost entirely from the sands, gravels and fractured rocks, through which alone the oil can move at an appreciable rate. It is obvious, therefore, that large differences in the rate of movement of oil underground are to be expected, not only among different fields, but also in the same field.

When a hole is drilled into a body of sand or gravel tightly filled with oil, one of three things will happen. (1) The liquid will rise in the tube until the height of the column thus formed equals the pressure in the reservoir. (2) If conditions are such that there is no gas pressure, and but little hydrostatic head, the liquid will rise only a few feet in the well and must be pumped out. (3) If the hydrostatic head is large, the oil will rise much higher, and may even flow quietly out at the top. If the reservoir contains not only liquid, but also gas, confined under pressure, the gas may force the oil to the surface with a strong flow, and in some well-known cases has even burst forth with sufficient violence to wreck the derrick. These may be considered as forming a fourth category.

The first of these conditions is characteristic of the Kern River field; the second is found in varying degrees in most of the California fields. The third is not common, but the fourth exists in the Buena Vista Hills, the Coyote Hills, certain parts of the East Coalinga field and the Sunset Flat, and in a few other small areas.

In the best part of Naval Reserve No. 2 the gas pressure is relatively strong, but it must be evident that, as the gas continues to flow out from the numerous wells already drilled, the gas pressure in each individual layer of sand, often called a "reservoir," is bound to decrease. For typical individual wells, this decline is shown by the pressure curve in Plate XXXVII. That it affects likewise the field as a whole is proven by the fact that the total yield of gas from the naval reserve is now falling off.

Since it is the gas pressure which causes the wells to flow in large volume, it is also clear that the production of wells, both existent and future, within the naval reserve, must decrease progressively, except in so far as there may be subsidiary anticlinal folds or additional layers of sand which have not been penetrated by wells. There is some reason to think that exceptions of this character exist, but it is tolerably well established that they are not of major consequence in the reserve.

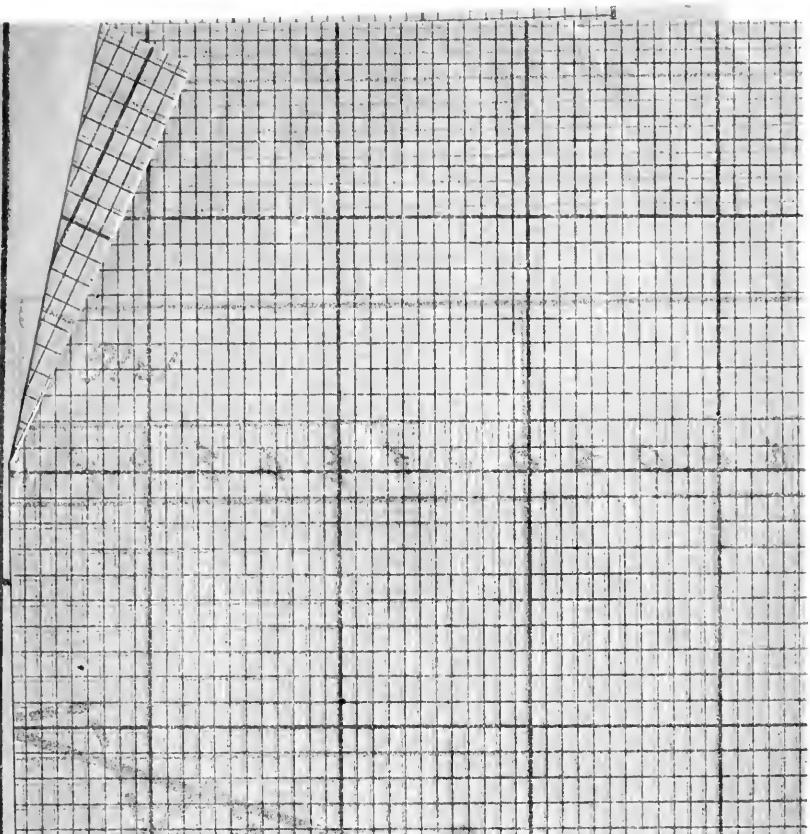
On account of the relatively slow movement of oil, even in sand beds, the draft of liquid into a given well is strongest in the immediate vicinity of the latter, and decreases in all directions, except as influenced by variable porosity and other factors. It is to be expected that when wells are subsequently drilled in the vicinity of the first one, they will have some influence on the amount of oil and gas flowing to the latter. That this is not merely an academic theory, as some people profess to think, is indicated by the histories of many wells reported to the committee from different localities. A few of these examples should suffice to indicate the truth of the statement.

The curves on Plate XXXVIII, which are reproduced through the courtesy of one of the companies operating in the naval reserve, show clearly how the flow of the old well decreased as soon as the new well began flowing at a distance of 930 feet from it.

The performance of two wells in the west side field of the Coalinga District is shown by the curves in Plate XXXIX. In this case the first well had been producing for seven months, by the time the second well was brought in, and had established the usual regular curve of decline. These wells stand about 350 feet apart.

Some critics have stated the opinion that such influences are of very small lateral extent. In this connection, we cite the following case taken from near the center of the Buena Vista Hills anticline. A well that had been flowing vigorously for several months, stopped suddenly on the day that a "gusher" well was brought in at a distance of 1,850 feet. Effects at even greater distances have been reported from the Midway field.

In view of the rather low viscosity of the oils in the reserve and the gas pressure exerted upon them, it is reasonable to expect such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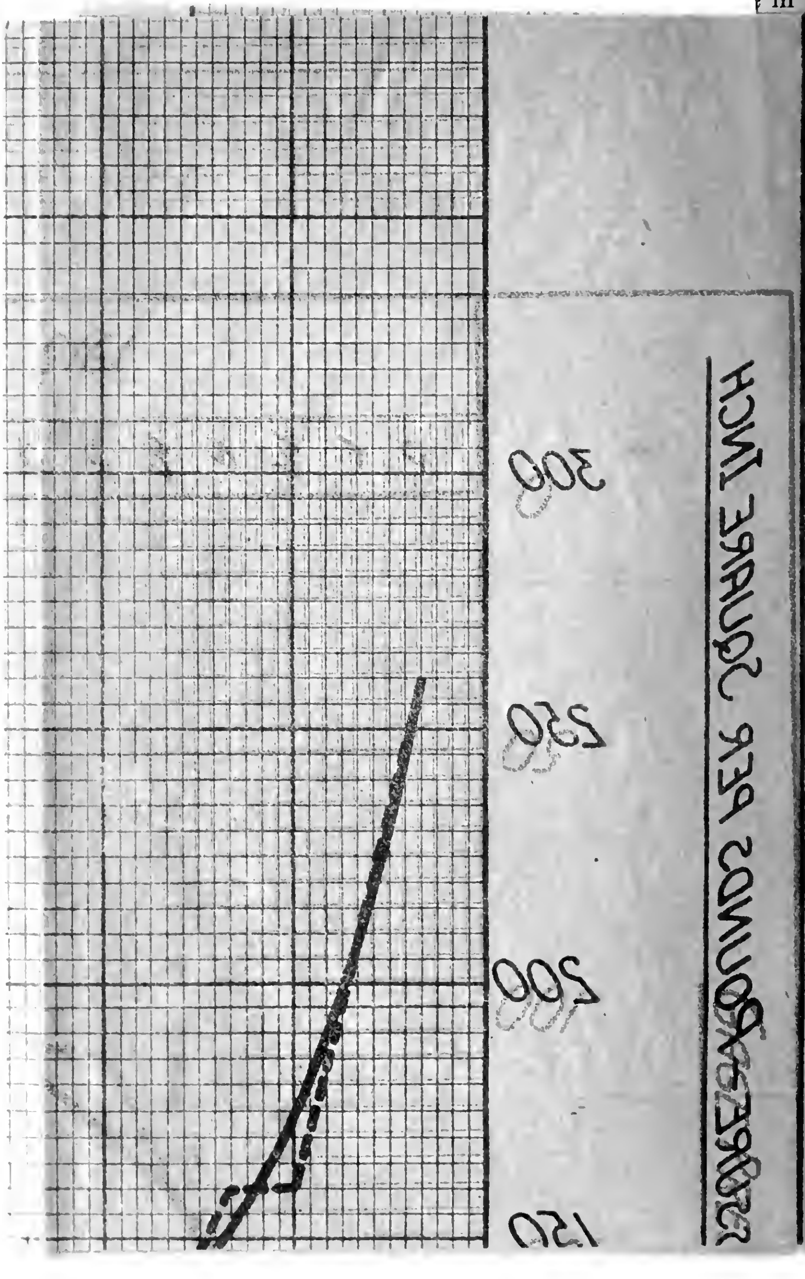

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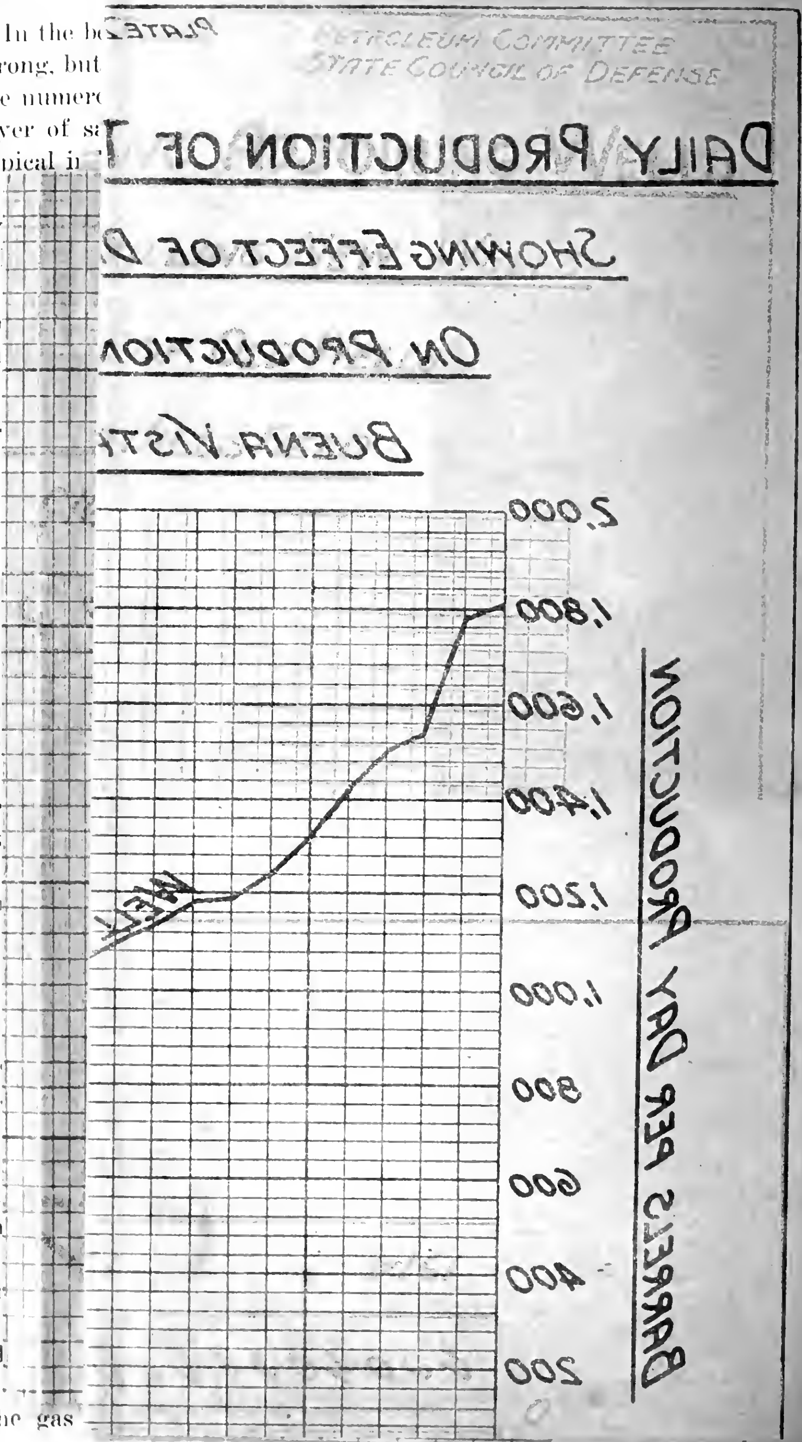

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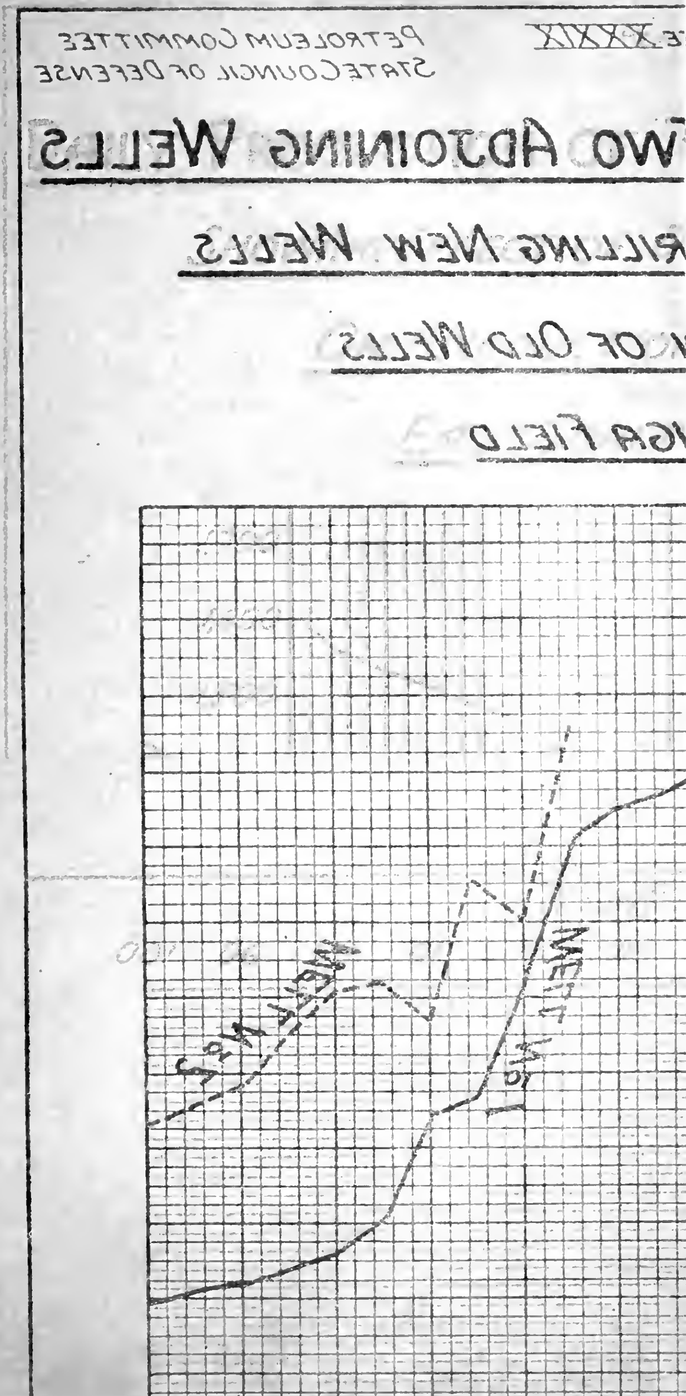

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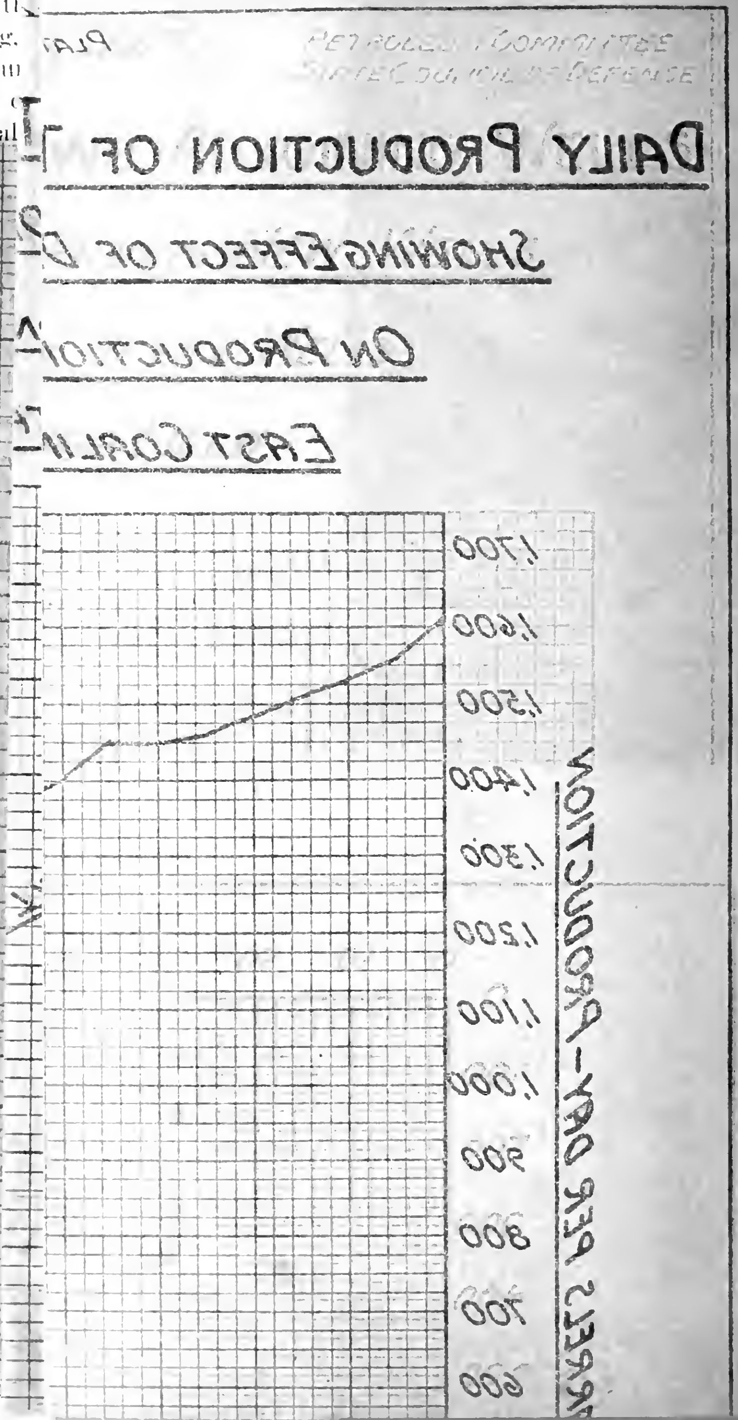

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sympathetic relations between wells to be stronger there than in most fields.

In setting aside Naval Reserve Number 2, it is said to have been the government's intention to keep a large supply of oil for the use of the Navy in future decades. In a closed anticlinal structure, not penetrated by wells, such a reserve would doubtless be essentially permanent. This seems to be practically true of Naval Reserve Number 1 in the Elk Hills. In the heart of Naval Reserve Number 2, however, there are patented lands, which have been intensively drilled, and others on which drilling is in progress, for reasons which need not be detailed here. There is reasonable ground for doubt that these wells could ever draw out all the available supply of oil from the reserve. That would depend on the number, shape and distribution of individual oil-bearing sands, and, perhaps, on other factors. In any case, it would take twenty years or more to effect the depletion fully. There is scarcely room for doubt, however, that very large quantities of oil have been, are being, and will be withdrawn from the reserve by these wells. The United States Geological Survey is quoted as estimating that at least 20 per cent of the oil will be so extracted, even if certain precautions are taken by the government. Furthermore, owing to exhaustion of the gas, which supplies the very force that makes this a region of highly productive flowing wells, it is far within the bounds of probability that Naval Reserve Number 2 will become, in time, an area of pumping wells of relatively low productivity, like the western portion of the Midway field. Then the remaining oil will be extracted at greater expense, and much more slowly than today.

Hon. Franklin D. Roosevelt, Assistant Secretary of the Navy, has suggested (article in "Petroleum Age," November, 1916) a plan to keep the reserve intact. He says: "We * * * must not allow private concerns to take out oil from any portion inside of the outer limits of such a reserve. Any child knows that oil flows to a greater or less extent over large areas underground, and government oil lands must be absolutely and definitely protected against tapping from other sources." This would seem to imply that the federal government should exercise its right of eminent domain and buy back most of the lands which have been patented within the reserve, cap or cement the existing wells, and thus completely stop production within the reserve until the oil is wanted.

Unfortunately even this revolutionary step would be impractical, unless the government wished to throw away the millions of dollars of investment, represented by the existing wells, by completely cementing the holes so far as they pass through the oil-bearing zone. If this precaution were not taken, and the wells were merely capped at the top, there would be danger of admitting water to the oil sands, through

the rusting out of casing, and also of permitting the escape of gas to the surface. These dangers have been pointed out by Mr. C. Naramore in his testimony (June 23, 1917), before the United States Senate Committee on Public Lands. At that time he voiced the opinion that the best thing the government could do to protect the reserve would be to buy the patented lands, including those within the reserve belonging to the Southern Pacific Company, in case the company wins its suit, "and then work the wells that are already drilled, at their minimum economic production, and have competent men in charge, so that if anything should go wrong with any of the wells, they would be able to repair the wells."

We think that Mr. Naramore has stated a fact in saying that Naval Reserve Number 2 is "valuable for present storage, but as matter of permanent storage, it is a thing of the past."

c. PRUDENT DISTRIBUTION OF DRILLING

After the best available lands for drilling have been selected, it would not be wise to drill them all at once in solid blocks, even if the necessary materials and crews could be obtained. Such a course is ordinarily advisable only in certain small areas that are unusually well known geologically. On the contrary, it tends to insure against failure if the wells are drilled in lines, one at a time. By this process the operators can feel their way, as it were, and mark out the limits of the productive territory with the minimum loss through putting down dry holes. They can also get invaluable information regarding the position of water-bearing layers, so that they may know just where such water ought to be shut off. In some districts it is practicable to drill only a few wells at a time, because the supply of water for drilling purposes is adequate. This is true in some parts of the Coalinga and Sunset fields.

The importance of this matter will be readily understood, for if only four or five, or even eight or ten wells are to be drilled in each section of land at one time, it will require a larger acreage in order to drill, say 100 wells, in a given number of months, than would otherwise be necessary. There are probably certain sections in California that would alone yield all the increase now necessary if they were entirely drilled up at once, but for the reasons indicated, it would be a dangerous plan to pursue.

This need of large acreage means either that many companies must be engaged in the operation at once, or that a few companies must operate on large holdings. It has been proposed, in connection with bills pending before congress, to restrict the size of leases on withdrawn government oil lands to even a single square mile. If such a policy is adopted, it will tend to put the development of petroleum lands out of the hands of those companies most efficient in handling the business.

4. Transportation Facilities.

It is an unfortunate fact that some good oil producing territory in California is without adequate transportation facilities. As long as that condition remains, an increase of production in such areas would serve no useful purpose.

In the San Joaquin Valley pipe lines which have ample capacity to transport all the oil which the fields in that part of the state can be expected to produce in the near future are already available. The distribution and ownership of these pipe lines are shown on Plate VI. As previously indicated. some readjustments and arrangements could well be made so as to eliminate a substantial part of the railroad transportation of oil that now takes place. A considerable number of cars could then be freed for service in regions which are not served adequately by pipe lines.

In the southern California fields the situation is quite different. At present the output of the wells in Los Angeles, Orange and Ventura counties, as well as those in the Santa Maria region, is either piped to the coast or transported eastward by rail. That which goes to the coast is shipped, either after or without refining, by tank steamers to various points along the Pacific coast of America and to countries farther west. At present all of the marketing companies report a great shortage in both tank steamers and tank cars, but especially in the latter. For example, at the El Segundo refinery, on June 15, 1917, the company was short more than 3,500 tank cars. or over one month's normal supply. They were loading at that time on an average of 30 to 40 cars per day, although the maximum capacity of their loading equipment is more than 250 cars per day. The company is using all of its present storage facilities, and is continually building more tanks, and yet it is not able to fully keep pace with the production of the tributary wells east of Los Angeles. For this reason it has been found necessary to reduce the flow of some of the wells until the means of transportation can be increased.

The General Petroleum Corporation has a pipe line from the Midway district south to San Pedro and Los Angeles. If the pumps on this line should be rearranged so as to carry the oil northward instead of southward, as at present, and if the company could be induced to make this readjustment, it would be possible to take care of the present and much of the future increase of production of the southern fields so far as the market in California alone is concerned. Even in that event, however, the acute shortage of oil in southeastern California. Nevada and Arizona, and particularly in the great copper mining districts of the latter state, would remain unrelieved. That region can apparently be served only by a substantial increase in the number of tank cars available.

The above considerations show that unless the necessary cars and ships can be supplied no amount of increase in production in the southern fields will be of any practical value to the state or nation in the present emergency. In that case we should be obliged to look to the San Joaquin Valley fields for all of the necessary increase. It is of the utmost importance to bear this fact in mind in considering our estimates of possible increase in production, as given later in this chapter.

5. Operators.

In view of the growing scarcity of oil, and the important place it holds in the nation's economy, it is the obvious duty of the oil producer to extract the maximum amount of oil from his land with the minimum damage to the surrounding lands. To accomplish this to the fullest degree, requires not only business ability and skill, but thoroughly scientific handling of the work.

In the past, great damage has been done to the oil fields of the state through the ignorance and incapacity of certain operators. By allowing gas to flow out unchecked, the pressure, which causes wells to flow, has been greatly decreased. By allowing wells to become choked with sand, particularly when first brought in, many good wells have been ruined or have required expensive redrilling. Most serious of all, water has been allowed to invade the oil sands and to create widespread damage in certain areas. Of course, it should be said in partial defense of these companies, that some years ago the conditions and their remedies were not understood as well as they are now, and hence mistakes were unavoidable. Fortunately, the state of California has now empowered the State Mining Bureau not only to investigate these facts, but to compel the observance of proper precautions, especially against water. Had this been done ten or twenty years ago it would probably have saved the state many millions of barrels of oil now irreparably lost; would have saved the companies themselves many thousands of dollars, and would have made it much easier to conserve the oil that still remains.

There are certain companies operating in the California oil fields which present a welcome contrast in this respect. By employing specially trained geologists and engineers to keep accurate records, and to advise regarding procedure in drilling, they are able to remedy water troubles effectually, to detect oil sands that might otherwise be overlooked and lost, and to greatly reduce the proportion of failures in drilling. They have adopted the most up-to-date methods of drilling, the use of specially designed screen-casing to prevent the sanding up of wells in gusher territory, and are continually increasing their efficiency as new ideas are developed.

It is a fact, which must be noted, that these companies are enabled to carry on the work with a high degree of efficiency, partly because of their size and ample resources. A company with large land holdings, especially if the lands are concentrated, can plan a consistent and intelligent drilling campaign, that would be impossible with a large number of small companies without that closeness of cooperation which is almost unattainable. They are also able to exhaust the oil sands one at a time, beginning with the uppermost, without being forced by competitors to drill into deeper sands at once in order to protect themselves. They are, furthermore, able to employ permanently men of the highest ability and skill, and enable them to become thoroughly acquainted with their properties. It is obvious, also, that they can effect economies in management, the purchasing of supplies and the disposal of the products. The reply that some of these companies have not always passed these economies, or a reasonable share of them, along to the public or back to the small producer has nothing to do with the present question. That is something which can and should be regulated by some form of government intervention, if no other means is adequate.

We think the facts which have been presented are sufficient to indicate that it would be of especial advantage to the country, at this crisis, to have the new drilling campaign carried on as far as possible by those companies which have developed the most efficient practices.

6. Capital.

The larger operating companies appear to have ample capital at their command to continue, and also to greatly increase, production, even in the face of greatly increased cost of materials. On the other hand, some of the smaller companies report that, at present prices for oil and drilling supplies, they can not afford to drill new wells. This is particularly true of those whose lands are in territory that is only moderately productive. Furthermore, many of the operating companies, whose lands are involved in federal suits, have a large part of their resources tied up because the proceeds from their wells are being deposited in escrow, pending the settlement of the litigation.

Viewing the state as a whole, however, we conclude that the deficiencies of capital are not of serious consequence, from the point of view of the nation, although they are obviously of painful importance to individual companies.

7. Incentive.

With oil selling at the wells for substantially \$1.00 per barrel or more, it would seem that there is sufficient incentive for a very active drilling campaign throughout the state. In addition, some of the larger companies have pressing needs for oil, and are thus compelled to drill. We

are also assured that a feeling of obligation to assist the nation in increasing the petroleum supply in war time is a factor of considerable importance just now.

On the other hand, many of the smaller companies, having long time contracts for the sale of oil at less than 50 cents per barrel, are not benefited by the rise in price, and are, therefore, hindered from taking up new drilling plans.

However, there appears to be ample incentive for the larger producing companies, which we estimate would, by themselves, be able to supply the increase needed, if other conditions were favorable.

From the above survey of the factors involved, we conclude that an important increase in production can be obtained in the shortest time by drilling many wells on land where the oil sands are at moderate depths, where general conditions of drilling and production are favorable, where flowing wells may be expected, and where ready transportation is available.

IV. *Possibilities of Securing the Required Increase.*

1. Amount.

There is plenty of oil in the ground, not only for the present war emergency but also for several years more. Our immediate problem is, therefore, not one of reserve supply but of making the supply available under the hindering conditions which now exist.

An examination of Plate XXXIV will reveal the number of new wells of various productivities that would yield the requisite increase in one year if they were all drilled at the beginning of the year. In actual practice the drilling would of course be spread over at least several months and hence the number required would be somewhat greater. From the nature of the diagram, it becomes obvious that wells which yield but a few barrels per day must be left entirely out of consideration, for, under the best circumstances, hardly more than 1,500 new wells could be drilled in California during the next year and the actual number may not reach even half that.

In order to make an accurate prediction of the increase in oil output that is possible, under existing conditions, it would be necessary for the committee to be possessed of superhuman knowledge of the interaction of several variable factors. Under these circumstances it is necessary for us to make certain assumptions, to generalize from average quantities obtained from the various reports at our disposal, and then to make certain necessary allowances and corrections. It will be obvious that at best there is rather large room for error at many points. There will be some tendency, however, for these errors to equalize each other.

The following method has been pursued: we first classified the lands

in the various oil fields with reference to their ability to yield a large quantity of oil in 12 to 18 months with a moderate expenditure of material and labor. Lands which seemed likely to average less than 100 barrels per well per day during the first year were omitted, for the reasons given above. The necessary facts about individual wells were furnished by the various producing companies and by the State Oil and Gas Supervisor, Mr. R. P. McLaughlin.

On the same basis, the better lands were then subdivided into three classes. Class "A" includes those likely to give wells of large production with a relatively small outlay of material and in a relatively short time. Nearly all of this is flowing well territory and occasional gushers are possible. Classes "B" and "C" are correspondingly less favorable in respect to production, particularly, but also as regards material and time. On account of the varying value of the factors, these classes can not well be given numerical expressions.

We then estimated, from the most recent maps of the fields, the number of acres as yet undrilled in these parcels of land and the number of wells that in wise practice could advantageously be drilled on them. The result of this estimate for the different fields is given in Table 26.

From the foregoing data, we have estimated the expectable production of the different tracts of land, as shown in Table 27. In this connection it must be observed that the committee assumed (*a*) that all necessary materials, supplies and water would be available as fast as needed, (*b*) that there would be no shortage in labor, (*c*) that the lands now withdrawn from development would become available, and (*d*) that those in control of the lands could and would actually cause the drilling to be done. At the same time, certain corrections have been applied as follows: (*a*) fifty to one hundred per cent extra time, over the average for the district, in order to allow for accidents and unforeseen delays, (*b*) five per cent deduction for failure of that proportion of the wells to produce adequately, (*c*) ten to twenty per cent added to our estimates for such materials as casing, rope and so forth, which are very difficult to calculate in advance, (*d*) five per cent deducted to offset the abnormal or sympathetic decline of the wells now producing in the same areas, that would be caused by drilling new wells adjacent to them. These corrections are admittedly very rough approximations.

The committee has deemed it best not to list the lands combined in these estimates nor to represent them on a map, as such specific information might later be used for some ulterior purpose by selfishly interested parties. The information is, however, deposited in the files of the committee and can be produced whenever a legitimate need arises.

An inspection of Table 26 reveals a number of general facts. Nearly all the best undrilled productive territory in California is comprised in

the Buena Vista Hills and the Coyote Hills. All of the desired production might be obtained from these two fields, or the first alone, within a few months time, if the saving of casing and particularly the economy of time should prove to be of critical importance. On the other hand, with somewhat more time available and with decided improvement in various conditions, it would be possible to obtain all the increase outside of the naval reserve. In our judgment, however, it is futile to expect an adequate increase from the lands which are at present free from suit, for it will be noted that the best of these lands have in general been more heavily drilled than any others, and at the same time they contain but a small part of the total acreage.

2. Time.

The time necessary for the drilling of the wells varies with a number of different factors. Of these, depth of well is one of the most obvious. Another is the use of the rotary as against the standard type of drilling tools. As shown in the diagram (Plate XXXVI), more rapid drilling is done by the rotary method, but under some circumstances it is advisable to use the standard, on account of the fact that it gives much more accurate information regarding the formations passed through and has some other advantages.

Efficiency of the drillers and general good management of the company have much to do with the speed of drilling. It is important to have all equipment and supplies furnished promptly and in such a way as to give the minimum of lost time and effort. There is at present much variation in regard to this among the companies.

Natural conditions affect the drilling operation to a variable degree in different fields. In general, drilling can be carried on most rapidly in regions where the rocks are relatively soft and uniform but yet stable, and also where serious difficulties with water-bearing sands are not encountered. Where such troubles are found, it is necessary that the drillers should know exactly what they may be and where to expect them. Serious delays are often caused by accidents, the loss of tools, collapse of casing and finally by the sanding up of the well after it is brought in, thus deferring its actual production and in some cases even causing its abandonment, with the necessity of drilling it over again.

The present average rate of drilling wells in all California districts is shown in Plate XXXVI. As a matter of fact, there are large variations within districts and even within small areas in the same district, depending upon the influence of the factors mentioned above.

An estimate of the amount of time required to change California's present stationary or declining production to an increased production

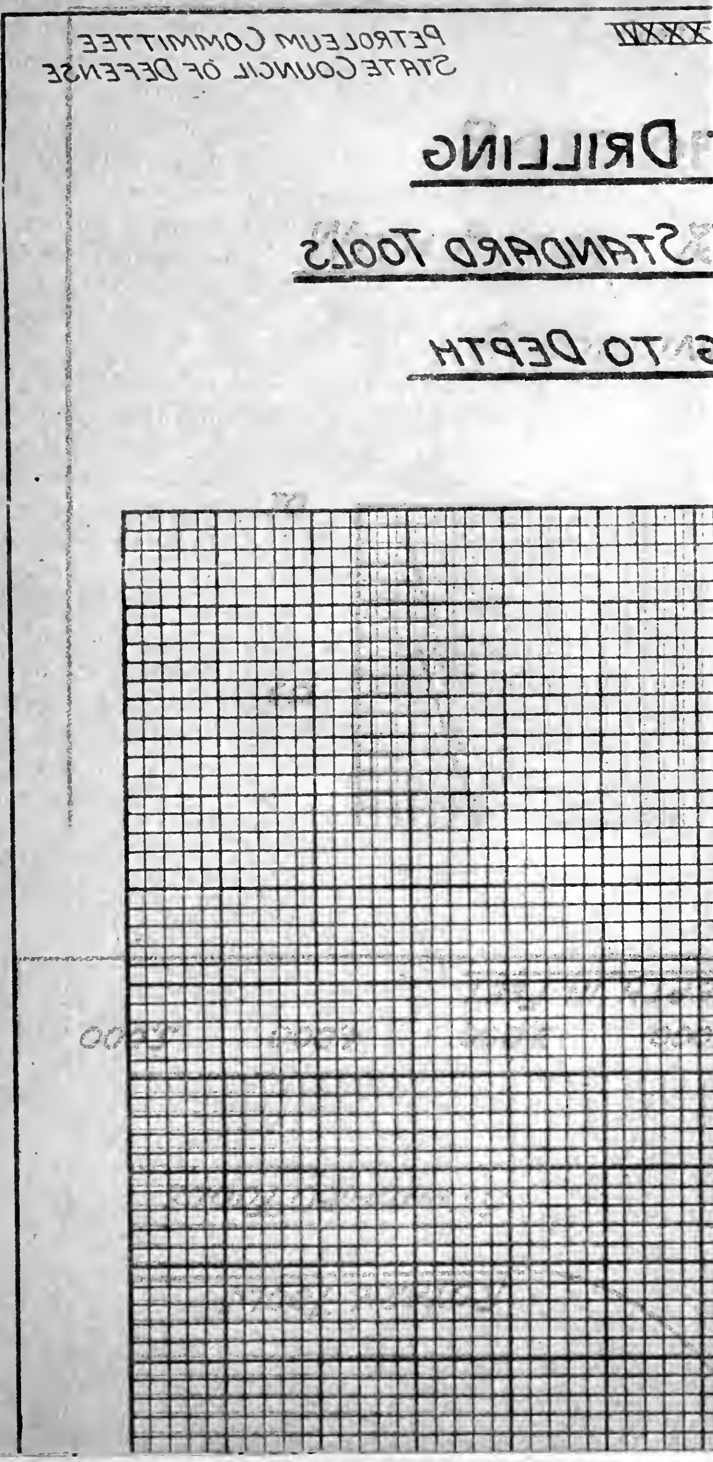

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PLATE

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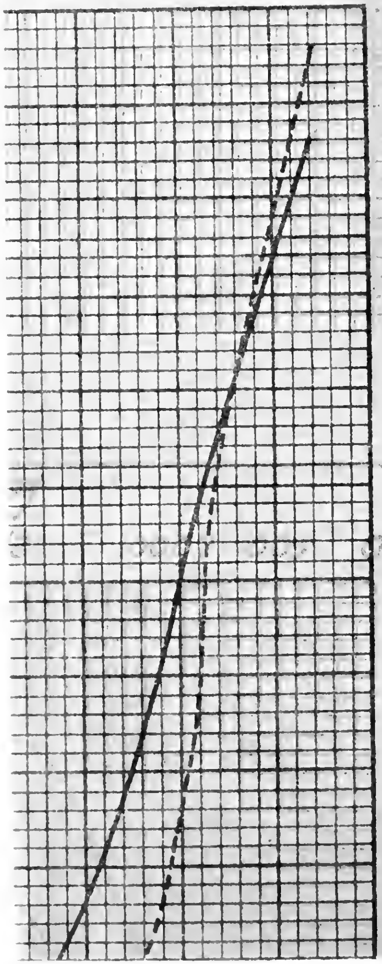

amounting to more than 35,000 barrels per day, depends upon the effects of many conflicting factors. Field superintendents of two of the largest companies operating in California have estimated that it would require about one year to produce their share of the increase. In making this estimate they took into account their past experience and made due allowances for the usual loss of time through various causes. We have carefully made independent calculations on this point, but on a somewhat different basis (as explained on page 000). In order to find out how fast the required increase could possibly be supplied we assumed a set of conditions that would be ideal; and yet they are all possible, at least with sufficient assistance by the federal government.

On this basis we estimate that it would be possible to increase the present daily production by more than 35,000 barrels in from three to four months after the drilling should begin.

It is of the greatest importance, however, to bear in mind that the assumptions which have been made are unduly favorable. Drilling material is scarce, the supply in sight being conservatively estimated at perhaps enough for 600 average wells. In some areas there is a deficiency of water for drilling purposes, and to supply this would require expensive construction of water mains, wells, pump stations, etc. Many of the drilling crews in the state are being used on lands which are not highly productive. From data furnished by the State Oil and Gas Supervisor we have calculated that during recent months (January, 1916, to April, 1917), not counting failures, 68 per cent of the new wells drilled yielded less than 100 barrels, and 40 per cent less than 50 barrels, per day. These wells are nearly all profitable to their owners, but, in view of the shortage of materials, not to the country. Furthermore, we estimate that not more than one-fourth of the crews could be obtained for drilling on the lands classified herein as A, B and C, unless the federal government should commandeer their services and assign them to work upon those lands. This condition is due to the pressing business needs of many companies and to clauses in many lease contracts demanding the drilling of new wells at specified times. About three-quarters of the lands in question are now either partly or wholly closed to drilling on account of litigation, and this ratio is much higher in the San Joaquin Valley, from which, on account of transportation difficulties elsewhere, it may be found necessary to obtain all of the increase.

For these reasons we conclude that the estimates made by the engineers, above mentioned, that at least a year will be required to bring about the necessary results, are much nearer to the actual attainments we may expect. Nevertheless, any relief from the conditions now

tending to restrict the development of the oil fields should operate to shorten the time materially in the direction of our idealized estimate.

The relative importance of the factor of time, as compared with that of material supplies, depends largely upon how soon the increase is required. If the increase must be ready in six months, or even by the end of 1917, then time is the critical factor. If the limit can be extended to July, 1918, as we think it can, then materials and transportation facilities are of greater moment, and hence speed of drilling should be sacrificed to economies in material and ships. In either case only very good lands will suffice. Considering the time which will necessarily be lost in making the various arrangements and readjustments before the work is actually brought into full swing, we conclude that, even so, the present rate of bringing in the new wells will need to be increased in order to meet the needs of the case.

V. *Summary.*

1. Most Favorable Lands.

If the entire state is considered without any reference to lands which are in litigation or have been withdrawn from development, and without reference to transportation facilities available for bringing the oil to points of utilization, we conclude that the best lands are in the following fields, in the order of their probable productivity per unit of material, labor and time:

(*a*) Buena Vista Hills (Naval Reserve No. 2).
(*b*) Coyote Hills.
(*c*) La Merced (Montebello).
(*d*) East Coalinga.
(*e*) Sunset Flat.
(*f*) West Coalinga and Syncline.
(*g*) Santa Maria.

Other good lands that are less favorable from the point of view of production per well, economy of materials and time, exist in the fields above mentioned and also in some others. We estimate that all these lands combined are capable of furnishing very much more than the desired 55,000 barrels per day additional production, provided supplies, labor and transportation can be furnished. Under similar conditions the required increase could be obtained in much less than one year, probably in four months, from the beginning of the intensive drilling.

In view of the desire of the Navy Department to preserve as far as possible the oil in the naval reserves, we have made separate estimates with reference to the lands outside of the reserves. As a result we believe that under the most favorable circumstances about 65,000 barrels per day increase could be obtained outside of the reserves. Of

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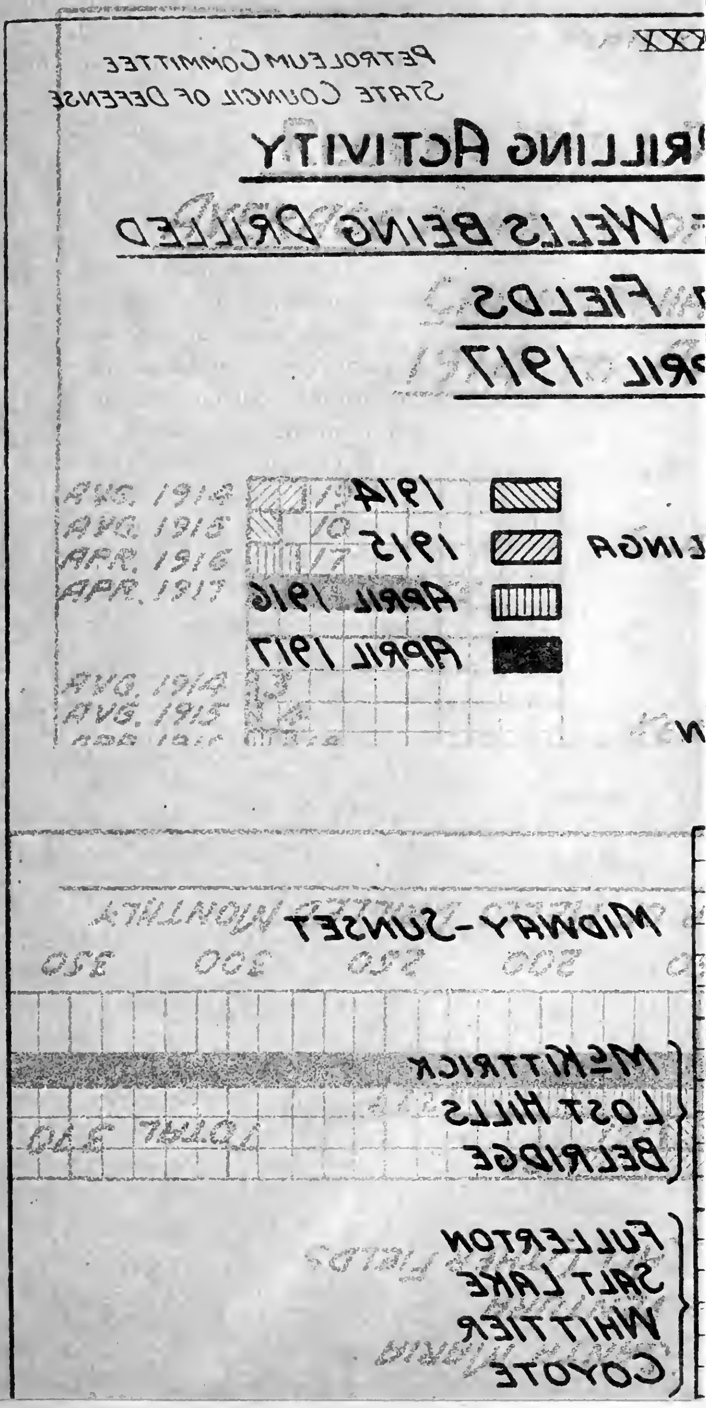

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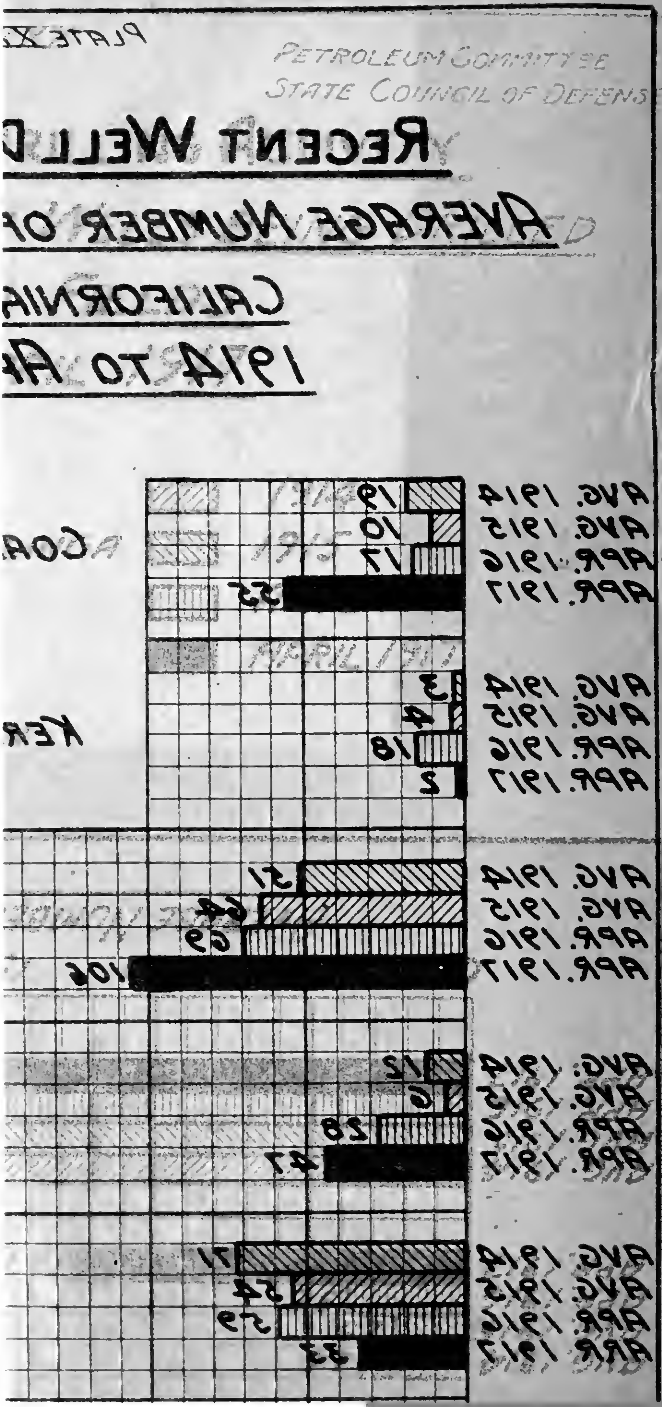


PLATE X
PETROLEUM COMMITTEE
STATE COUNCIL OF DEFENSE
RECENT WELL
AVERAGE NUMBER OF
CALIFORNIA
1914 TO AP
AVG. 1914
AVG. 1915
APR. 1916
APR. 1917
19
10
17
55
3
4
18
2
51
64
69
106
12
6
28
47
71
54
59
33

this amount nearly one-half would have to be drawn from the southern and coast districts, which are at present not supplied with adequate transportation facilities. We are of the opinion that scarcely three-fifths of the necessary increase could be obtained from lands outside the naval reserves in the San Joaquin Valley, where alone these facilities are now available.

2. Agencies of Production.

It is, of course, obvious that drilling on the lands not in suit must be done by the owners of the land or under their supervision, unless the government takes some action that would be revolutionary in its nature. We think it has been amply demonstrated that the development is likely to be carried on most effectively by those companies which have already acquired the necessary experience and detailed understanding of local conditions and have shown conspicuous ability in the management of their properties. By far the greatest part of the lands above mentioned are already either owned or claimed by companies of which this may be said. We do not presume to discuss any of the complicated questions regarding the legal status of claimants to these lands or matters of justice and ethics involved in the existing disputes. We urge, however, that an equitable settlement of these important questions be reached as soon as practicable.

3. Necessary Arrangements to Be Made.

We are convinced that without the following arrangements which in nearly all cases can be made only by or with the help of the federal government, it will be impossible to obtain the required increase in production or perhaps even to maintain the present production. It is absolutely essential, first, that a large part of the valuable lands now withheld from development be made available as quickly as possible; second, that adequate supplies of material be made available as fast as required, and third, that most of the workmen be retained in the oil fields. Unless the very best lands are used it will also be necessary to supply additional tank steamers, and, in any event, it will be necessary to increase the rate of delivery of tank cars. It is also possible that sufficient activity can not be stimulated without some form of governmental inducement or compulsion, directed by a commission or other suitable agency.

CHAPTER XI.

CONSERVATION.

As hereinbefore indicated, two possible means of meeting the shortage in California petroleum have occurred to us—first, increased production and, second, decreased consumption. In Chapter X we considered the first of these alternatives. In the present chapter we shall consider the second.

We shall address ourselves herein to the possibility of conserving California petroleum after it has reached the surface of the ground.

The word "conservation" will be used in this chapter in a broad sense to include the diminution of field losses, the higher use of petroleum and its products, and the substitution of other fuel or power.

The subject will be considered with reference both to the emergency created by the war and to the more normal conditions which should prevail after the termination of the war.

The subject matter of this chapter will be considered under the following heads:

I. Diminution of field losses.
II. Higher use of petroleum and products.
III. Substitution of other fuel or power for California fuel oil.
IV. Conclusion.

I. *Diminution of Field Losses.*

The conservation of California petroleum through the diminution of field losses is a matter which has received and is receiving serious consideration in the oil fields of California.

The principal losses in the field may be classified as follows:

1. Losses incidental to the bringing-in of high pressure wells.
2. Losses from seepage, evaporation and drainage.
3. Losses due to inefficient field use.

1. Losses Incidental to the Bringing-in of High Pressure Wells.

Between the time when a high pressure oil well is "brought in" and the time when it is brought under control, some loss of oil in many cases occurs in any high pressure territory. Where drilling is carried on by competent men who understand the characteristics of the district in which they are operating, losses due to uncontrolled wells are very small and do not constitute an important factor in the problem of conservation. At the present time these losses in the California oil fields may be disregarded.

2. Losses From Seepage, Evaporation and Drainage.

Seepage, evaporation and drainage losses are dependent largely upon the gravity of the oil and upon the care which is exercised to prevent waste. During any period of low prices, losses from sumps, tanks and storage reservoirs may become quite large due to lack of care on the part of field operators and because at such times the movement of oil from well to pipe line may be slow by reason of excess production. At the present time, however, when storage is rapidly becoming depleted and the oil movement from the well to pipe line is accomplished with as little delay as possible, these losses have been reduced to a negligible amount.

3. Losses Due to Inefficient Field Use.

Approximately 8,500 barrels of marketable oil are used daily in the California oil fields for pumping and other well operations. While we do not wish to be understood as indicating that all field uses of petroleum are unnecessary, it is apparent after careful investigation that further economy can be and should be practiced by field operators.

During the early years of petroleum development in California, a very large amount of fuel oil was burned under the boilers of small and unnecessarily inefficient steam boilers, and this condition continued during the period of overproduction and low prices. During the last two or three years, however, central steam plants have replaced to a large extent the individual pumping stations theretofore relied upon for power in those fields where natural gas is not available in sufficient quantities to meet the power requirements.

In the gas producing fields of the state individual gas engines have largely replaced steam power and in certain districts, particularly in Coalinga and Kern River fields, electric power for field pumping is being rapidly substituted.

Electric motors amounting to a total of between 6,000 and 7,000 horsepower are now in use in the San Joaquin Valley oil fields for pumping and cleaning wells. These installations at present effect a saving of not less than 14,000 barrels of crude petroleum per month. The number of electric motor installations for oil well operations is rapidly increasing, due partly to the present high price of oil and partly to the general policy of conservation which has been adopted by most of the large operators.

It is not unreasonable to expect that, through the use of electric motors, gas engines and larger and more efficient steam plants, the field uses of petroleum will be reduced to possibly half of the present uses.

These are considerations, however, largely for the future. Relief will come largely from the use of new equipment in the operation of new wells. The difficulty in obtaining motors, gas engines and steam boilers during the present emergency will force, for a time at least, a partial

continuation of obsolete and wasteful methods in connection with existing installations, in order that new equipment may be devoted to new wells brought in under the campaign of intensive drilling which will be necessary in order to maintain production.

II. *Higher Use of Petroleum and Products.*

We have given careful consideration to the possibility of conserving California petroleum and its products by the higher use thereof.

The subject will be considered under the following heads:

1. Burning of unrefined petroleum.
2. Improved refining processes.
3. Internal combustion engines.
4. Automobiles.

1. Burning of Unrefined Petroleum.

It is an economic crime to burn unrefined petroleum.

Approximately 40 per cent of California petroleum is now used as fuel under boilers without having been refined. While a considerable part of the fuel oil burned by California railroads and other industries is being refined, it is nevertheless true that very large amounts thereof are burned after having had only one cut taken therefrom or without any refining or topping whatsoever. Tests made in the laboratory of the Railroad Commission of California of fuel oil taken from oil tanks of various railroads of California, ready for burning by these railroads, showed that the oil had a range of gravity up to 21 degrees Baume, and that several cuts of distillates and lubricating stocks can be taken therefrom.

Other forms of fuel or power can in time take the place of fuel oil; but to date there are no satisfactory substitutes for gasoline or lubricating oils.

We are strongly of the opinion that as soon as possible steps should be taken, by governmental authority, if necessary, to prevent the further burning of unrefined petroleum.

2. Improved Refining Processes.

Improved refining processes, by which by-products in increasing amounts are extracted from the crude petroleum, are a high form of conservation.

It is gratifying to note that the California petroleum refineries are all working on improved processes of refining and cracking and that the percentages of gasoline, lubricants and other valuable products of petroleum secured by them from a given amount of crude oil are constantly increasing.

This subject is more fully discussed in Chapter VII of this report entitled "Refining of California Petroleum," to which chapter reference is hereby made.

3. Internal Combustion Engines.

Internal combustion engines of the Diesel and semi-Diesel type for units up to 1,000 horsepower continue to attract interest from the standpoint of small and medium sized stations. Following the government's announced policy of equipping at least a portion of the new cargo carriers now under construction with engines of this type, the Diesel engine has attracted renewed and widespread interest for marine installations.

Recent tests of eight Diesel plants in Texas, ranging in size from units of 170 horsepower to 550 horsepower, indicated thermal efficiencies of from 18 per cent to 29.7 per cent. These tests, however, were made under actual operating conditions with load factors ranging from 35.6 per cent to 64.2 per cent. Actual efficiencies under tests would probably show efficiencies slightly in excess of 30 per cent. The efficiency indicated, while only slightly higher than that obtained in recent tests of large turbo-generating units, is of particular interest when it is considered that the probable average efficiency obtained from steam engines of comparable size would not exceed 10 to 12 per cent. Notwithstanding the high thermal efficiency of the Diesel engine, little relief can be expected in the immediate future through the substitution of this type of engine for the less efficient small steam engine, for the reason that the greater cost of the Diesel engine, added to the cost of changing the existing installation, will effectively prevent any rapid change, at least during the present emergency.

Stationary internal combustion engines other than the Diesel type continue to show satisfactory progress where small units are required or where gas is available at low cost in quantities sufficient to justify their use in larger sizes. The thermal efficiency of the engines varies from 15 to 25 per cent.

In the various California oil fields where natural gas is available, internal combustion engines can be used to advantage and can be used more extensively than at present for the inefficient steam plants now furnishing power for pumping and other well operations.

4. Automobiles.

The number of automobiles in active use in the United States on January 1, 1917, was in excess of 3,250,000. What these figures mean from the standpoint of possible fuel requirements is clearly shown by a comparison with the nation's water power resources. The U. S. Geological Survey in 1908 estimated that the potential water power resources of the United States were 53,905,000 horsepower. This total is only 70 per cent of the horsepower capacity of automobiles in actual service at the beginning of 1917.

The average fuel requirement of all automobiles in the United States is variously estimated to be from 450 to 500 gallons of gasoline per year.

On the basis of the lower estimate, the annual gasoline requirement of the automobiles in this country at the beginning of the present year was 1,462,500,000 gallons, or about 34,800,000 barrels.

In California alone at the present time over 248,000 automobiles, with an aggregate power capacity in excess of 5,900,000 horsepower, are in active use. On the same basis of arriving at the fuel requirements hereinbefore used, the present yearly gasoline requirements of motor vehicles in California would be over 2,660,000 barrels, or about $51\frac{1}{2}$ per cent of the state's entire gasoline output.

Based on a comparison of the summer and winter use of gasoline for automobile fuel, and considering various other factors, it has been roughly estimated that 38 per cent of the automobile requirements are for what may be termed pleasure purposes. If this assumption is correct and the gasoline consumption of such "jitney" traffic as is unnecessary is added, it would appear that not less than 13,900,000 barrels of gasoline could be conserved in the United States each year during the war, if the national necessity were found to warrant the federal government in prohibiting the use of gasoline except for necessary commercial, industrial and military purposes. The corresponding saving of gasoline in California would exceed 1,000,000 barrels per year at the present rate of consumption.

Housewives may render material assistance by eliminating unnecessary store deliveries. The coordination of store deliveries will assist to the same end.

Whether the use of automobiles for so-called pleasure purposes should be curtailed or prohibited during the war, so as to conserve the gasoline for the higher uses of the Navy and the Army, and particularly for the use of our military aeroplanes, is a question of national policy equally applicable to all sections of the country, on which the federal government alone should and undoubtedly will speak if it should become necessary.

III. *Substitution of Other Fuel or Power for California Fuel Oil.*

In Chapter VIII we have pointed out the purposes for which, and the localities in which, California petroleum and its products are used.

Can any part of the California fuel oil thus utilized be saved by the substitution of other fuel or power?

In answering this question we shall consider the following subjects:

A. Other fuel oil.
B. Coal.
C. Powdered coal.
D. Hydroelectric energy.
E. Natural gas.

A. Other Fuel Oil.

It has been suggested that the shortage in California fuel oil may possibly be supplied, at least in part, by fuel oil from some other region. Mexico and Alaska are the only territories which have been suggested in this connection.

1. Mexico.

The present proved petroleum fields of Mexico are located on the east coast, inland from Tampico and Tuxpam and on the Isthmus of Tehuantepec.

According to official records of the de facto government of Mexico, prepared from reports furnished by all operating companies, as reported in the Oil Trade Journal of March, 1917, the total production of Mexican crude oil in 1916 was 39,817,402 barrels, an increase of 6,906,894 barrels over 1915. The exports in 1916 are reported by the same authority to have been 26,998,744 barrels, consisting of 21,183,728 barrels of crude oil and 5,815,016 barrels of refinery products. Mr. E. L. Doheny, president of the Pan-American Petroleum and Transport Company, Mexican Petroleum Company, and other Mexican oil companies, testified, on June 20, 1917, before the Committee on Public Lands of the United States Senate, that in 1916 approximately 40,000,000 barrels of petroleum and its products were shipped from Mexico, of which amount approximately three-fourths came to the United States. Mr. Doheny has advised us that due to increased marine transportation facilities the exports of Mexican petroleum for 1917 will exceed the exports for 1916 by approximately 13,000,000 barrels.

Referring to the possibility of increased petroleum production in Mexico, the Oil Trade Journal of March, 1917, at page 76, reports as follows:

> "To show how strenuously the production of Mexico is held in check with scarcely any drilling in marvelously rich territory, it is only necessary to compare the present average production of about 136,000 barrels a day with the conservatively estimated capacity of the completed wells, which is over 600,000 barrels a day. Not more than one-fifth of the possible production of Mexico's wells is marketed and stored. It is agreed by authorities that the petroleum output of Mexico could be raised to 1,000,000 barrels a day if requirements demanded it or transportation facilities were available."

From the information available to us it appears that the Mexican petroleum fields are capable of very largely increased development and that in normal times, with adequate transportation facilities, Mexican petroleum will be able to a considerable extent to meet the demands made on a diminishing California production. For this purpose Mexican petroleum can hereafter be transported through the Panama Canal or through a pipe line to be constructed to the west coast of Mexico and

thence by water. The possibility of securing Mexican petroleum after the war will be a factor of tremendous importance to the Pacific coast, which has learned to rely on California petroleum.

Prior to 1916 Union Oil Company of California was under contract to deliver approximately 2,750,000 barrels annually of California fuel oil in Chili, principally for the operation of the nitrate fields. This fuel oil was transported from California to Chili in tank vessels leased by Union Oil Company.

Under contract between Union Oil Company and one of the Mexican oil companies controlled by Mr. E. L. Doheny, fuel oil to supply the Union Oil Company's requirements in Chili is now sold to the latter company at Tampico and transported through the Panama Canal to Chili, thus releasing an equal amount of California fuel oil. Delivery under this arrangement commenced on January 29, 1917, and amounted to 1,050,000 barrels from January 29 to May 18, 1917.

After making this arrangement and as a result thereof Union Oil Company sold 1,000,000 barrels and loaned another 1,000,000 barrels of fuel oil to Kern Trading and Oil Company for consumption by Southern Pacific Company and sold 1,000,000 barrels and loaned another 1,000,000 barrels to Associated Oil Company, to enable that company to meet its requirements.

Excluding the amount of fuel oil transported by Union Oil Company to Chili, approximately 3,000,000 barrels of California fuel oil were delivered in 1916 at points on the west coast of Mexico, Central America and South America, and at the Panama Canal. We believe that a considerable portion of this fuel oil can be supplied from the east coast of Mexico, thus relieving an equivalent amount of California fuel oil and to this extent alleviating the shortage of California petroleum.

Can any further amount of California fuel oil be released during the war by the substitution of fuel oil from Mexico?

It has been suggested that Mexican fuel oil can be brought to the lines of the Southern Pacific Company at some point in Texas and used to operate the Southern Pacific Company's Tucson Division, extending from El Paso on the east to Yuma on the west. During the spring of 1917 the Southern Pacific Company consumed 7,111 barrels of fuel oil daily on the Tucson Division.

It is not suggested that this fuel oil can be brought from Tampico to Texas by water. The present shortage of oil tank steamers is a matter of common knowledge. Although a number of such steamers are now under construction for the purpose of transporting Mexican oil, it is not intended that they shall transport oil for use on the lines of the Southern Pacific Company and it is by no means certain that these vessels will not be requisitioned by the federal government.

The suggestion has been made that the problem can be solved by the

transportation of fuel oil from Tampico to Texas in tank cars over the National Railways of Mexico and thence over the lines of the Southern Pacific Company west to El Paso and other points on the Tucson Division.

Whether the National Railways of Mexico are in a position to handle this traffic is not knwon. In the "Official Guide" of this railroad appears the following notation:

> "On account of disturbed conditions in Mexico and the irregularity of train service, the National Railways of Mexico has temporarily ceased to publish the usual train schedules."

We know that a considerable portion of the line of the National Railways of Mexico is in deplorable physical condition. Assuming that the line were available for operation, oil tank cars would move from Tampico to San Antonio, Texas, a distance of approximately 729 miles, or from Tampico to Eagle Pass, Texas, a distance of approximately 615 miles, or from Tampico to El Paso, a distance of approximately 1,070 miles, to points of connection with the lines of the Southern Pacific Company.

At the present time, assuming the very high average daily mileage of 75 miles per car, 298 oil cars are in constant service to and from Los Angeles, to meet the requirements of the Tucson Division, as follows:

Oil station	Daily requirements	Distance from Los Angeles	Tank cars needed
Yuma	4 cars	250 miles each way	28
Gila	4 cars	372 miles each way	44
Tucson	6 cars	500 miles each way	78
Bowie	3 cars	614 miles each way	51
Lordsburg	4 cars	664 miles each way	76
Cambray	1 car	750 miles each way	21
			298

Assuming delivery from Tampico over the National Railways of Mexico to the Southern Pacific lines at El Paso, Texas, and thence to points on the Tucson Division, and assuming again an average performance of 75 miles per car per day, 832 oil tank cars would be in constant use as follows:

Oil station	Daily requirements	Distance from Tampico	Tank cars needed
Cambray	1 car	1,131 miles each way	31
Lordsburg	4 cars	1,219 miles each way	133
Bowie	3 cars	1,260 miles each way	103
Tucson	6 cars	1,374 miles each way	223
Gila	4 cars	1,503 miles each way	165
Yuma	4 cars	1,626 miles each way	177
			832

It is inconceivable that the railroads of Mexico should be able in their present condition to transport oil tank cars 75 miles per day. If a 25 per cent correction factor is supplied, at least 1,040 oil tank cars would be in constant use if Tampico oil were transported to Southern Pacific Company's Tucson Division, with delivery at El Paso. This number is approximately 700 tank cars in excess of the number now necessary to supply the Tucson Division with fuel oil from Los Angeles.

The total number of tank cars owned by the Southern Pacific Company's Pacific System is reported by the company to be 2,572, of which 300 are in special service, 109 leased to the Pacific Electric Railway Company and the Southern Pacific Company's Atlantic System, 1,035 in commercial service, approximately 128 in bad order and 1,000 in the company's fuel service, of which latter number 500 are employed in the Southern District and 500 in the Northern District. Seven hundred oil tank cars could not be taken by the Southern Pacific Company from its commercial service without seriously disturbing existing industries which are dependent upon the fuel oil transported by these cars. We have been unable to ascertain from what source the Southern Pacific Company could at this time reasonably secure the necessary number of additional oil tank cars for this service.

Due to the high viscosity of Mexican fuel oil considerable time would be required to make the necessary changes in the Southern Pacific Company's locomotives on the Tucson Division. Furthermore, the necessity of transporting 700 additional oil tank cars on its Tucson Division would seriously interfere with the efficient transportation by the Southern Pacific Company of persons and property for the federal government and otherwise.

In view of the present and prospective transportation difficulties, we are of the opinion that it will not be possible to utilize Mexican fuel oil, during the period of the war, to supply any substantial part of the uses now being supplied by California fuel oil, with the possible exception of a part of the fuel oil used on the west coast of Mexico, Central America and South America, and constituting approximately 3 per cent of the entire production of the state.

2. Alaska.

In 1916 California shipped 475,000 barrels of fuel oil to Alaska, of which amount 73,000 barrels were used by steamship companies, 8,000 barrels by other public utilities, 342,000 barrels by mining and smelting companies, 10,000 barrels by other commercial enterprises, and 41,000 barrels for other purposes. During the same year California shipped to Alaska approximately 94,000 barrels of the products of petroleum, principally distillates and gasoline.

The fish canning and other industries of Alaska are largely dependent on vessels propelled by distillate or gasoline.

About eight or nine producing oil wells, yielding only eight to ten barrels each daily, have been developed in the Katalla fields near Controller Bay in Alaska. The oil has a paraffine base and is valuable for the production of gasoline and distillate, but not for fuel.

With the exception of one 140-acre tract which was patented, all other petroleum lands in Alaska have been withdrawn from entry by the federal government and further development thereon stopped. In any event, there is no assurance that Alaska would have a large production.

Under existing conditions it is doubtful that during the war any part of California petroleum and the products thereof now shipped to Alaska can be released by the production of petroleum in Alaska.

B. Coal.

We have given careful consideration to the possibility of substituting coal, at least in part, for California fuel oil.

We shall consider the situation separately as to (1) California and (2) the Northwest.

1. California.

California produces only a negligible quantity of marketable coal. In this respect her situation is similar to that of the west coasts of Mexico, Central and South America and Hawaii.

a. Sources of Coal Supply.

California has heretofore secured coal principally from Australia, British Columbia, eastern United States (by water), Washington and Oregon, and the Rocky Mountain States.

Table 28 is condensed from the 1916 report of the San Francisco Chamber of Commerce and shows the receipts of coal in tons at San Francisco in 1916.

TABLE 28.

Receipts of Coal in Tons at San Francisco, 1916.

Year	*Foreign overseas	British Columbia	Washington	Oregon	Rocky Mountain coalfields	Eastern U. S. by water
1908	243,284	167,415	29,426	24,885	----------	171,875
1909	97,286	179,187	25,557	24,470	----------	76,081
1910	202,414	166,443	65,085	13,572	----------	86,744
1911	163,816	200,646	59,128	4,655	10,930	154,789
1912	97,089	173,753	49,829	1,200	19,080	122,090
1913	170,801	40,297	66,344	950	47,250	126,668
1914	162,548	97,598	12,637	73	39,030	60,219
1915	98,603	147,573	1,208	320	68,055	92,128
1916	8,115	213,442	33,528	----------	104,850	----------

*Australia, Great Britain, Japan and China.

As appears from the foregoing table, the importation of coal into San Francisco from the eastern part of the United States by water ceased entirely in 1916. The importation from Australia and other overseas countries ceased in May, 1916. In 1916 San Francisco was compelled to rely for her coal on British Columbia, the Rocky Mountain States and Washington.

In 1916 Los Angeles consumed 60,000 tons of coal, of which 43,000 tons were shipped from the Utah and Wyoming fields and 17,000 from New Mexico. During the first six months of 1917 the shipments of coal to Los Angeles are reported to have been but 50 per cent of the 1916 shipments, due largely to the shortage of labor at the mines and in part to transportation conditions.

In considering the possibility of securing coal for California during the war, we are at once confronted by the impossibility of securing coal from Australia and other overseas countries and also from the eastern part of the United States, due to the lack of vessels. We are advised that there is a serious shortage of labor in each of the remaining coal fields on which California has heretofore relied, particularly in British Columbia.

The situation is made more critical by transportation difficulties, both by land and water.

With reference to the possibility of securing coal from Alaska, we are advised by Honorable Franklin K. Lane, Secretary of the Interior, by telegram dated June 12, 1917, as follows:

> "Alaska coal surrounded with such difficulties of topographic and geographic character that development will be slow and should not be relied upon for supplying Pacific coast for one or two years. Plans for developing these fields being pushed by department as much as possible. Some coal now being mined for use on government railroad."

During the winter of 1916–17, California experienced considerable difficulty in securing even the relatively small amount of coal which the state required for domestic purposes.

The increasing seriousness of the labor situation at the coal mines on which California must rely and of the transportation situation show the futility of relying on coal to any material extent during the war to take the place of fuel oil now used in California.

b. Relative Prices of Fuel Oil and Coal.

Whether fuel oil or coal will prevail as a fuel would ordinarily depend upon the play of well known economic forces, among which are the relative price of the two fuels, bearing in mind their relative efficiency, and the convenience of their respective use.

Pacific Gas and Electric Company, which company has made a careful study of this subject, reports to us that the average heating value of coal heretofore sold in California and adjacent states, and produced in Colorado, New Mexico, Washington, Wyoming and Utah, has been approximately 11,933 British thermal units per pound of dry coal. Assuming a boiler efficiency of 65 per cent, 7,150 British thermal units would be available from this coal. California fuel oil has a heating value of approximately 18,500 British thermal units per pound and can be burned with an efficiency of 75 per cent, so that the boilers absorb 13,870 British thermal units from each pound of oil. Consequently, one pound of fuel oil is equal, for steaming purposes, to 1.94 pounds of coal of the character hereinbefore referred to. One ton of this coal, containing 2,000 pounds, would therefore be equivalent to 3.07 barrels of oil, or approximately three barrels.

The price of California petroleum of between 14 and 17.9 degrees Baume gravity is now 98 cents per barrel at the wells, and $1.45 per barrel delivered on San Francisco Bay. The price of coal at San Francisco is indefinite at the present time. Coal dealers report that they are securing between $10 and $11 per ton for small quantities. Assuming, merely for the purpose of the illustration, that coal could be secured at San Francisco in large quantities for $8.00 per ton, fuel oil would have to advance to $2.66 per barrel before it would be equivalent in price to coal, without giving consideration to the investment necessary for conversion from oil to coal.

It is evident that at the present relative prices of fuel oil and coal in California, few consumers of fuel oil will voluntarily give up its use and revert to coal if they can have an assurance of a continued supply of fuel oil.

c. California Railroads.

Because of their large use of fuel oil and the seriousness, from the public point of view, of their particular problem, we have given special consideration to the situation of the railroads which are operated by California fuel oil. These railroads include the principal railroads of California, Nevada, Oregon and Arizona, a part of the railroads of Washington, Utah and New Mexico and a part of the Canadian Pacific Railway in Canada.

We shall now consider the situation of the principal railroads which burn fuel oil in whole or in part in California and the adjacent states to the east, and shall hereinafter consider the situation of the railroads and other industries of the Northwest.

The five principal railroads of California are the Southern Pacific Company; The Atchison, Topeka and Santa Fe Railway Company, herein referred to as the Santa Fe; the Los Angeles and Salt Lake Railroad Company, herein referred to as the Salt Lake; the Western

Pacific Railroad Company, herein referred to as the Western Pacific; and the Northwestern Pacific Railroad Company, herein referred to as the Northwestern Pacific.

California fuel oil operates the Southern Pacific Company's lines in California, east through Arizona and New Mexico to El Paso, Texas, east through Nevada to Ogden, and north to Portland, Oregon; the lines of the Santa Fe in California and east to Winslow, Arizona, and also one-third of the road locomotives from Winslow east to Gallup, New Mexico, as well as the switch engines at Winslow and Gallup; the lines of the Salt Lake in California and northeast through Nevada to Milford, Utah, as well as freight locomotives from Milford northeast to Lynndyl, Utah; the lines of the Western Pacific in California and east through Nevada to Wendover, Utah; and the entire lines of the Northwestern Pacific from San Francisco north to Eureka, California, with the exception of the company's interurban electric system in southern Marin County and a small branch line on which wood is burned.

Table 29 shows with reference to each of these railroads the lines on which California fuel oil is used, the number of barrels of fuel oil used in 1916, the daily average in 1916, the number of barrels of fuel oil used in January to April, inclusive, 1917; the daily average January to April, inclusive, 1917; the total use in barrels for 1917 as estimated by the respective railroads, and the estimated daily average for 1917.

TABLE 29.

Fuel Oil Consumption of Specified California Railroads.

Lines on which California fuel oil is used		Barrels fuel oil used, 1916	Daily average, 1916	Barrels fuel oil used Jan. to April, inclusive, 1917	Daily average, Jan.-April, inclusive, 1917	Estimated total use, 1917, in barrels	Estimated daily average, 1917
Southern Pacific	Pacific System to El Paso, Ogden and Portland	14,120,538	38,412	5,088,239	42,402	16,000,000	43,835
Santa Fe	San Francisco to Winslow, Arizona	4,871,818	13,347	1,802,834	15,024	5,421,330	14,853
Salt Lake	Los Angeles to Milford, Utah	1,242,632	3,404	422,052	3,517	1,266,156	3,469
Western Pacific	San Francisco to Wendover, Utah	1,059,074	2,902	356,335	2,969	1,080,000	2,969
Northwestern Pacific	San Francisco to Eureka, California	550,290	1,508	165,968	1,383	594,428	1,629
Totals		21,844,352	59,573	7,835,428	55,295	24,161,914	66,755

The foregoing table gives data with reference to only the five principal California railroads. As will be observed, the average daily consumption of these five railroads from January to April, inclusive, 1917, was 55,295 barrels, which amount was approximately 21 per cent of the entire California production during this period.

We shall now consider in somewhat more detail the fuel oil situation of each of these five railroads, with a view to thereafter considering the possibility of substituting coal for all or a portion of their fuel oil requirements.

SOUTHERN PACIFIC COMPANY.

The Southern Pacific Company secures its fuel oil principally from the production of a subsidiary corporation known as Kern Trading and Oil Company. A relatively small amount of fuel oil is purchased by Kern Trading and Oil Company from third parties.

Table 30 shows the fuel oil situation of the Southern Pacific Company during the months ending March 31, 1917, April 30, 1917, and May 31, 1917.

TABLE 30.

Southern Pacific Company—Fuel Oil Situation—March, April and May, 1917.

	Month ending Mar. 31, 1917 (barrels)	Month ending April 30, 1917 (barrels)	Month ending May 31, 1917 (barrels)
Net production of Kern Trading and Oil Company	749,983	699,131	685,657
Borrowed from Union Oil Company	1,375	112,856	145,333
Purchases and royalty of oil from lessees of railroad lands	81,850	72,157	132,917
Net amount received by Kern Trading and Oil Company on account of exchange of lighter oil for fuel oil	68,192	44,828	96,211
Total receipts	901,400	928,972	1,060,118
Fuel oil consumption of Southern Pacific Company	1,260,212	1,200,750	1,253,299
Excess of consumption by Southern Pacific Company over receipts	358,812	271,778	193,181
Daily excess of consumption by Southern Pacific Company over receipts	11,575	9,060	6,232
Oil stocks in storage tanks of Kern Trading and Oil Company	789,028	590,577	480,067
Oil in storage tanks of Southern Pacific Company	738,094	742,702	786,217
Oil purchased from Union Oil Company and not yet delivered	1,000,000	1,000,000	1,000,000

On the basis of the returns for the month of March, 1917, it appeared that the Kern Trading and Oil Company's storage, together with the 1,000,000 barrels purchased from Union Oil Company, would be consumed by the Southern Pacific Company in approximately five months, or by September 1, 1917, at which time it would be necessary

for the Southern Pacific Company to enter the market and purchase fuel oil from the amount stored by the principal companies, particularly the Standard Oil Company and Union Oil Company. The returns from later months, however, indicate that under existing tendencies the Kern Trading and Oil Company's stocks and the 1,000,000 barrels purchased from Union Oil Company will not be exhausted until December, 1917.

While the amount of oil held in storage by Kern Trading and Oil Company decreased from 789,028 barrels on March 31 to 590,577 barrels on April 30 and 480,067 barrels on May 31, 1917, it is also true that the average excess of daily consumption of fuel oil by the Southern Pacific Company over receipts decreased from 11,575 barrels in March to 9,060 barrels in April and 6,232 barrels in May. The Southern Pacific Company reports that up to June 12, 1917, it had not as yet taken any fuel from Union Oil Company under the purchase contract.

It will be observed from Table 30 that the net production of Kern Trading and Oil Company decreased from 749,983 barrels in the month of March to 699,131 barrels in April and 685,657 barrels in May. Attention should be drawn, however, to the fact that Kern Trading and Oil Company is engaged in a very active campaign of drilling operations in some of the best undrilled territory in the Midway, Sunset and Coalinga fields. The land on which these wells are being drilled is all Southern Pacific Company land now in litigation with the federal government. Under the so-called "gentlemen's" agreement between Southern Pacific Company and the government in the Southern Pacific suits, Kern Trading and Oil Company can drill no wells which are not "defensive" wells. This agreement precludes any intensive development of any of the Southern Pacific lands, although they are among the best undrilled lands in the state.

In the early part of June, 1917, Kern Trading and Oil Company was engaged in erecting derricks and had commenced drilling new wells, or was about to do so, as follows:

Coalinga Field.

In section 11, township 19 south, range 15 east, M. D. M., contracts were let for the erection of derricks at wells Nos. 51, 52 and 53. Contracts were likewise let for the drilling of wells Nos. 52 and 53. Kern Trading and Oil Company proposed to drill well No. 51 with its own tools.

On section 35, township 19 south, range 15 east, M. D. M., contractors were at work rigging up on wells Nos. 44 and 45. Contracts for wells Nos. 41, 71, 72 and 46 were agreed upon and the construction of derricks was commenced.

Sunset Field.

In section 31, township 12 north, range 23 west, S. B. M., derricks were completed on wells Nos. 58, 59, 60 and 61. Contracts were let for

drilling wells Nos. 60 and 61 and Kern Trading and Oil Company commenced work with its own crews on wells Nos. 58 and 59.

In section 5, township 11 north, range 23 west, S. B. M., derricks were being erected on wells Nos. 62, 64 and 65 and contracts for drilling these wells had been agreed upon. Actual drilling operations were awaiting the arrival of drill stem from the east.

Midway Field.

In section 1, township 32 south, range 23 east, M. D. M., in Naval Reserve No. 2, adjacent to Standard Oil Company's section 36, derricks were completed for wells Nos. 57, 58 and 59, and drilling was in progress on Nos. 57 and 59. Work was also being done on wells Nos. 56 and 41.

In addition to the wells hereinbefore referred to, Kern Trading and Oil Company, during the month of May, did considerable work on derricks and rigs for regular line locations on wells Nos. 15 and 21, section 25, township 31 south, range 23 east, M. D. M., in Naval Reserve No. 2, in the Midway field; wells Nos. 33 and 37, in section 19, township 32 south, range 24 east, M. D. M., in the Midway field adjacent to Naval Reserve No. 2 on the south; well No. 3 in section 17, township 32 south, range 24 east, M. D. M., in Naval Reserve No. 2, in the Midway field; and Nos. 3 and 5 in section 31, township 12 north, range 23 west, S. B. M., in the Sunset field.

As already indicated, these wells are all located in excellent oil territory and it must be assumed that when they are brought in they will add materially to the monthly net production of Kern Trading and Oil Company.

Attention should also be drawn to the fact that subsequent to March 1, 1917, Kern Trading and Oil Company has entered into contracts for the purchase of oil from third parties, as follows:

(1) Contract dated March 10, 1917, with Union Oil Company for the borrowing of 1,000,000 barrels of fuel oil, this oil to be returned to Union Oil Company within eighteen months. Deliveries are being made under this contract, as already shown.

(2) Contract dated May, 1917, with Richfield Oil Company providing for the delivery from date of the contract to January 1, 1918, of between 25,000 and 45,000 barrels of fuel oil per calendar month.

(3) Contract dated May 18, 1917, with Howard M. Payne, receiver, providing for the sale during one year from June 1, 1917, of one-half of the total production from the SE. $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of section 32, township 12 north, range 23 west, S. B. M., known as the McCutcheon property. The contract provides that the maximum delivery shall not exceed 10,000 barrels per month or 2,000 barrels per day.

(4) Contract dated May 18, 1917, with Howard M. Payne, receiver, providing for the sale during one year from June 13, 1917, of the total

amount of petroleum produced on the S. ½ of the S. ½ of the SE. ¼ of section 14, township 31 south, range 22 east, M. D. M., this property being claimed by Stockton Midway Oil Company. The contract provides for a maximum delivery of 10,000 barrels per month and 2,000 barrels in any one day.

(5) Contract dated May 19, 1917, with Inca Oil Company for a term of 12 months from May 19, 1917, providing for the sale of between 13,000 and 14,000 barrels monthly.

A few thousand barrels of oil have also been purchased under smaller contracts.

SANTA FE.

The Santa Fe secures its fuel oil from two subsidiary corporations, known as Chanslor-Canfield Midway Oil Company, operating in the Midway and McKittrick fields, and Petroleum Development Company, operating in the Whittier-Fullerton field. These companies secure their fuel oil in part from their own operations and in part by purchase from third parties.

The Chanslor-Canfield Midway Oil Company is now actively engaged in drilling operations in the Midway field. The company reports 151 producing wells and 31 drilling wells as of June 1, 1917, with a production during May of 280,634 barrels and an estimated production for 1917 of 3,290,000 barrels.

The Petroleum Development Company reports 70 producing wells and four drilling wells during the month of May, with a production of 50,820 barrels in May and an estimated production of 600,000 barrels during 1917.

The Santa Fe reports that through the production of these two companies and the oil which they have purchased it will be able to meet its requirements for fuel oil during at least the year 1917.

SALT LAKE.

The Salt Lake secures its fuel oil from Associated Oil Company under contract dated December 1, 1914, expiring on November 30, 1917, and providing for a maximum delivery of 7,000 barrels per day.

WESTERN PACIFIC.

The Western Pacific secures its fuel oil from Standard Oil Company under contract expiring on January 1, 1919, and providing for a maximum delivery of 90,000 barrels per month.

NORTHWESTERN PACIFIC.

Northwestern Pacific secures its fuel oil from Associated Oil Company under two contracts, the one dated November 20, 1915, expiring on January 31, 1918, and providing for a maximum annual delivery of 180,000 barrels, the other dated May 1, 1915, expiring on April 30, 1918, and providing for a maximum monthly delivery of 75,000 barrels.

d. Possible Conversion of California Railroads From Fuel Oil to Coal.

We shall now consider the facts bearing on the possibility of converting California railroads, in whole or in part, from fuel oil to coal.

SOUTHERN PACIFIC COMPANY.

Southern Pacific Company recently sent telegrams to 26 coal companies in Wyoming, Utah, Washington, New Mexico, Arizona and California, asking for definite information as to whether these companies could supply 18,000 tons mine run locomotive coal daily, beginning September 15, 1917, and asking for prices at the mines. Southern Pacific Company has submitted to us copies of the answers received from the 16 companies which replied. These answers indicate a possibility of securing only a part of this coal from Washington and Utah. No company reports definitely that it will be ready to deliver the entire amount of coal referred to in the Southern Pacific Company's telegram.

The Southern Pacific Company's Pacific system reports the ownership of 2,463 coal cars, which cars for a number of years have been employed and are now employed in transporting commercial traffic other than coal. The company reports that it would take between 4,000 and 5,000 coal cars to provide for a consumption of about 11,000 tons of coal per day, and states that such an amount of coal cars it not available. The conversion of any portion of a railroad system from fuel oil to coal presupposes the construction of bins for the storage of coal, trestles for unloading cars, tipples for loading engines, and other loading and unloading facilities, and the construction of cinder pits at all roundhouses and terminals. The Southern Pacific Company reports that it is doubtful whether the delivery of material for the conversion of locomotives from fuel oil to coal could begin much before January 1, 1918. The company reports that approximately 90 locomotives per month could be converted from oil to coal at an average cost of between $500 and $600 per locomotive.

Such engines would be kept out of service during the period necessary for their conversion and the Southern Pacific Company draws attention to the loss in efficiency of its operations during this period and also thereafter.

SANTA FE.

The Santa Fe reports that it would cost $1,044,500 to convert 486 locomotives from oil to coal, to equip 133 such locomotives with automatic stokers and to construct 20 additional mechanical coal chutes.

The company further reports that the only coal mines in operation contiguous to its oil-burning lines are at Gallup, New Mexico, and that the output of these mines for commercial purposes has fallen about 40 per cent, due to the scarcity of miners, who have been attracted by the high wages which are now being paid at the copper mines.

While it may be possible for the Santa Fe to convert its oil-burning lines east of Barstow, California, to coal, such conversion would require the expenditure of a large sum of money, would result in increased congestion of traffic by reason of the transportation of large numbers of coal cars, and would result in decreased efficiency of operation.

SALT LAKE.

The Salt Lake is at present burning coal on its lines from Salt Lake to Lynndyl, Utah, and on its passenger locomotives between Lynndyl and Milford, Utah.

The company reports that the estimated cost of converting its oil-burning engines to coal would be approximately $65,000 and that in addition thereto it would be necessary to construct facilities for handling coal at terminals and intermediate coaling stations at a cost of approximately $215,000.

The Salt Lake reports that it is now engaged in converting additional locomotives from fuel oil to coal, and that it hopes by the expiration of its fuel oil contract on November 30, 1917, to have converted to coal all locomotives from Salt Lake City west to Caliente, Nevada.

Coal is delivered to the Salt Lake by the Denver and Rio Grande Railroad Company at Provo, Utah.

WESTERN PACIFIC.

Western Pacific reports that it has 111 oil-burning engines, the conversion of which to coal would cost between $500 and $600 per engine. The company further reports that it would take from one to two years under ordinary conditions to convert these engines from oil to coal.

The company is now planning to convert its engines between Wendover, Utah, and Elko, Nevada, from oil to coal, the work to be done gradually as the engines pass through the shops. Even with this change the company reports that its increasing business will necessitate the use by it of the maximum amount of 90,000 barrels of fuel oil per month, specified in the company's fuel oil contract.

NORTHWESTERN PACIFIC.

The Northwestern Pacific reports that there are no coal deposits along its line, other than undeveloped lignite veins in the middle fork of the Eel River, and that it is impossible for the company to rely on coal at the present time.

The company reports that it would cost approximately $25,000 to convert its locomotives from oil to coal and that coaling stations and facilities would require an additional estimated expenditure of $30,000.

While such portions of California's railroads as are located in proximity to the coal mines of New Mexico, Utah, Colorado and Washington

could probably be gradually converted from fuel oil to coal, we are of the opinion that no very large saving of California fuel oil could be effected in this manner during the continuance of the war.

Attention should be drawn to the fact that such conversion means decreased efficiency during the period of conversion, loss of time and efficiency on the part of the locomotives after they have been converted and increased congestion of traffic due to the largely increased number of fuel cars which it would be necessary to transport.

2. The Northwest.

As shown in Chapter VIII, in 1916 California fuel oil to the extent of 17,500,000 barrels was delivered to Oregon, Washington and Canada, for consumption by railroads, steamship companies and industries.

We have given careful consideration to the question whether the consumers of fuel oil under these contracts would be likely, at their expiration, to turn to other forms of fuel or power, thus relieving California fuel oil.

Washington and British Columbia both produce large amounts of good commercial coal. In 1916 Washington produced 3,019,600 short tons of coal and 93,700 short tons of coke. The total production of British Columbia is not available to us, but it is significant that in 1916, 54 per cent of the entire importation of coal into San Francisco came from British Columbia. Reference has already been made to the labor shortage in both Washington and British Columbia.

We are advised that approximately 1,000,000 barrels of California fuel oil annually have recently been released in the Northwest by the substitution of coal at the expiration of fuel oil contracts.

One of the California oil companies was under contract to deliver 75,000 barrels of fuel oil per month at Portland for account of the Oregon-Washington Railroad and Navigation Company, also known as the Oregon Short Line. This contract expired on June 30, 1917. The oil company gave notice that the contract could not be renewed. We understand that the railroad company will henceforth use coal.

We are also advised that an annual consumption of 12,000 barrels of California fuel oil heretofore used by the city of Seattle has been released or will shortly be released and that a cement plant at Bellingham has recently been converted from fuel oil to powdered coal, at an annual saving of 84,000 barrels of California fuel oil.

On the other hand, Canadian Pacific Railway Company has refused to consider the conversion of its line of railway from fuel oil to coal and this company's contract was equated by extending its term ten months, based upon the then market price of $1.45 per barrel. A similar arrangement has recently been consummated with the Union Steamship Company of New Zealand, a large user of fuel oil in the Northwest. One of the California oil companies offered to pay the

larger part of the expense of installing a coal gas plant for Portland Gas and Coke Company in consideration of the cancellation of this company's contract, but was unable to secure the gas company's consent.

One of the best informed oil men of the state has advised us of his views with reference to the situation in the Northwest in part as follows:

> "My previous views on this subject have undergone considerable change of late, by reason of the anxiety shown by customers in that territory in the matter of securing contracts for their future fuel requirements. Originally I was of the impression that with a certain increase in the selling price of oil a large number of industries in that section would revert to the use of coal, and I expected the change to occur about the last of the year, when most of the larger contracts will expire. Much to my surprise such a situation does not seem imminent, and there is an apparent willingness to pay prevailing prices providing assurances can be given of the certainty of a supply.
>
> "Generally speaking, and with my present knowledge of the subject, I would say that the railways of the Northwest would not return to coal at this time even if compelled to pay \$1.65 per barrel for oil, and other consumers \$2 per barrel, providing a supply can be assured. The only exception to this is the cement plants, which will probably use powdered coal, although the development of this system has not proceeded to the point where it can be used with safety and economy in other lines of industry."

The president of one of the large oil marketing companies has advised the committee as follows:

> "The situation in the Northwest at the present time is such that the people are going to use oil just as long as they can get it, practically regardless of price. In other words, although they have coal properties, they are short of labor to the extent that it is practically impossible to get coal in sufficient quantities to take care of their requirements. On the other hand, under normal conditions, coal will displace oil very readily at the present prices of oil in that district. In other words, to the best of our knowledge, so far as the immediate future is concerned, there will be no saving of California oil through the shrinkage of usage in the Northwest."

Our general conclusion on the question of the possibility of the substitution of coal for fuel oil in the Northwest is that apart from the case of the Oregon-Washington Railroad and Navigation Company, no substantial amount of California fuel oil will be released during the pendency of the war, but that when conditions have become normal after the termination of the war, it is reasonable to anticipate the release of a considerable quantity of California fuel oil in the Northwest, if the existing prices for California fuel oil are maintained, the conversion to be to coal, and possibly to some extent to powdered coal.

C. Powdered Coal.

Our investigation into the possibility of substituting other forms of fuel for fuel oil, particularly in connection with the railroads, has led to a consideration of the subject of powdered coal.

Coal has heretofore been successfully used in powdered form in cement plants, stationary boilers or power plants, and in metallurgical furnaces for iron, steel and copper.

We are advised that three railroads in the eastern and central portions of the United States are at the present time experimenting with powdered coal as a substitute for coal on locomotives, but that certain difficulties have been encountered which have not as yet been completely eliminated. Many advantages are claimed for powdered coal over coal, but it is not necessary here to enumerate or analyze the same.

The California railroads are not united in their opinion with reference to the feasibility of the use of powdered coal on railroad locomotives.

The Southern Pacific Company reports that the use of powered coal on railroad locomotives is still in its experimental stage and that the results thus far seem to indicate that it will never prove successful.

The Santa Fe reports that it has erected two small plants in Missouri for experimental work and that experimental tests on one of its locomotives started on May 1, 1917. The Santa Fe refers to difficulty due to a curtain of conglomerate which forms on the flues and shuts off the draft. The Santa Fe is hopeful that the experiments with this form of fuel for use on locomotives will ultimately prove successful.

The Northwestern Pacific refers to the expense of equipping locomotives for consumption of powdered coal and of erecting the necessary plants for powdering and handling this fuel. This railroad states that it has been unable to secure advice with reference to definite results obtained from the use of powdered coal on railroad locomotives.

Powdered coal can be utilized only where coal is available.

In view of the coal situation in the territory in which California fuel oil is utilized and of the fact that to a considerable extent the use of powdered coal is still in an experimental stage, we are of the opinion that during the emergency created by the war we can not look to the use of powdered coal to any substantial extent as a substitute for California fuel oil.

D. Hydroelectric Energy.

The possibility of the further conservation of California petroleum and its products through a more extensive and efficient utilization of hydroelectric energy, both during the war and thereafter, has been carefully considered by us. The committee has had the benefit of two special reports dealing with the general problem, the one received from the Pacific Coast Section of the National Electric Light Association,

over the signature of Mr. H. F. Jackson, president, and the other from Mr. F. Emerson Hoar, gas and electrical engineer of the California Railroad Commission.

The problem of conserving fuel through the substitution of water power is not a new one in California and other Pacific Coast States, as will be apparent from the fact that hydroelectric development in California has increased 800 per cent in the last fifteen years. It is interesting to note that during the same period the production of petroleum increased less than 700 per cent.

The total installed capacity of existing hydroelectric plants in California, Washington, Oregon, Nevada and Arizona is about 1,288,600 horsepower, of which 731,000 horsepower, or 56.8 per cent, is in California. The combined output of these hydroelectric plants, if reproduced by steam power, would require the annual expenditure of not less than 19,000,000 barrels of fuel oil.

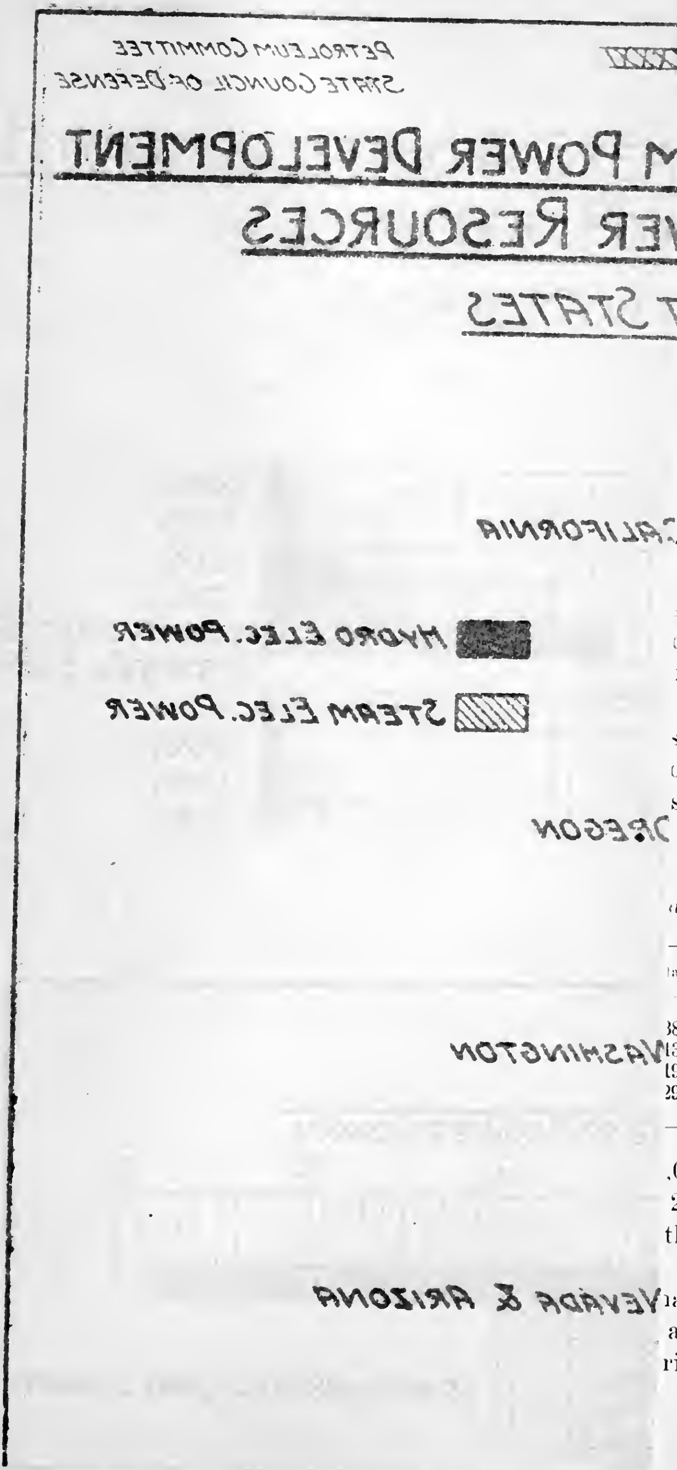
The minimum potential water power resource of California, according to estimates made by the U. S. Geological Survey in 1908, as revised by the Commissioner of Corporations in 1912 and by the Secretary of Agriculture in Senate Document No. 316, Sixty-fourth Congress, first session, is 3,424,000 horsepower, and the minimum combined resources of the five states mentioned is reported to be 12,619,000 horsepower, or 45 per cent of the water power resources of the entire country. Of these potential resources, approximately one-third can be developed as required at an average investment cost which will permit of successful and profitable operation under present conditions of the western power market. This information, over a ten-year period, is shown in tabulated form, for fifteen years, from 1902 to 1917, segregated by states, in Table 31.

TABLE 31.

Water Power Resources and Hydroelectric Development of Pacific Coast States in Horsepower.

Item	California	Oregon	Washington	Nevada	Arizona	Total
Minimum potential water power resources	3,424,000	3,148,000	4,928,000	172,000	893,000	12,619,000
Estimated practical developments under present conditions	1,100,000	950,000	1,200,000	20,000	280,000	3,550,000
Installed capacity of hydroelectric plants—						
1902	91,656	31,089	24,089	2,296	320	149,450
1907	216,150	138,779	67,714	6,812	934	430,389
1912	440,243	168,807	279,760	12,709	9,346	910,865
1917 (estimated)	731,000	176,800	333,600	13,500	33,700	1,288,600

The vast water power resources of California and other states now consuming California petroleum and its products are of particular



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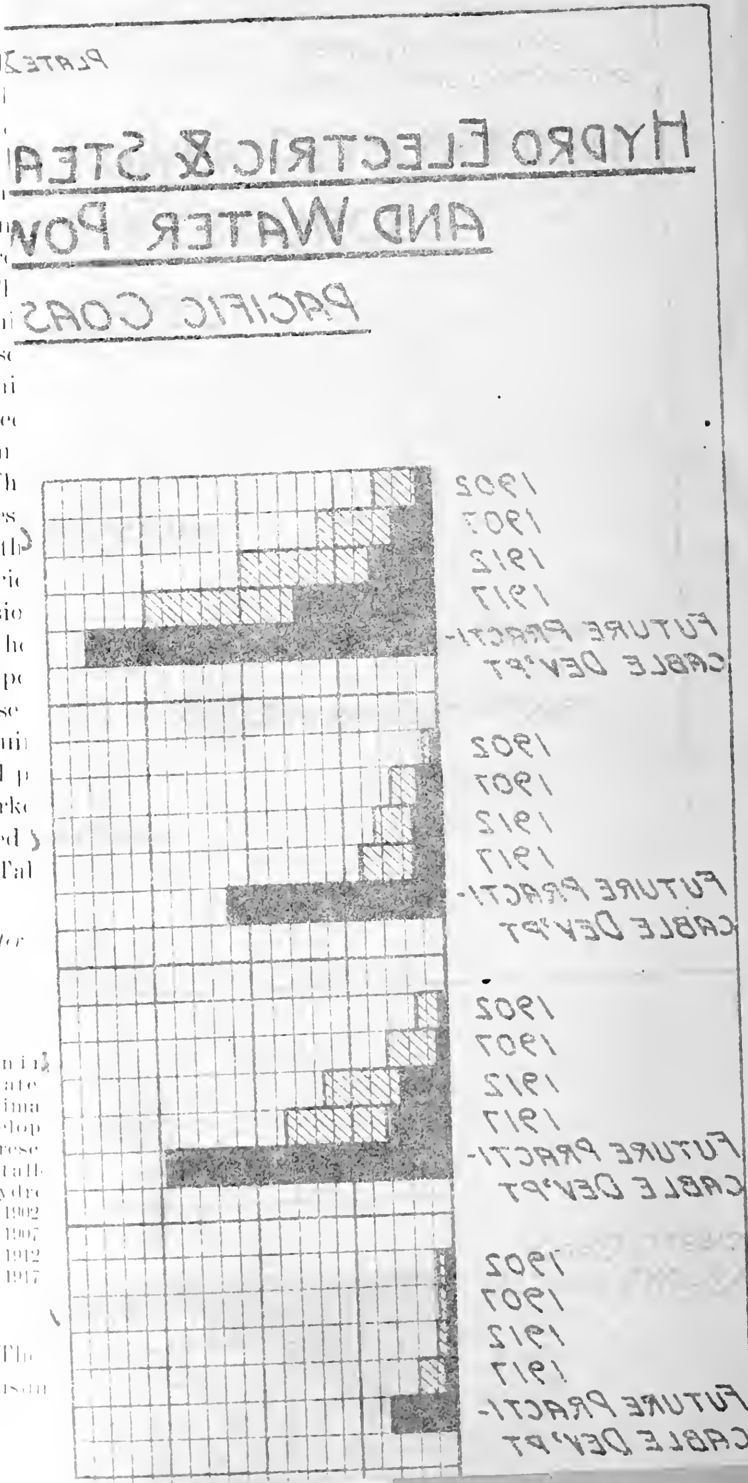

interest at this time because of the present critical situation affecting the supply of liquid fuels. The only relief, however, which may be anticipated from this source during the war will come from a more complete and efficient utilization of existing hydroelectric capacity.

At the present time over 21,500 horsepower of developed hydroelectric plants in California are not available for use in the industrial centers of the state, because of inadequate line capacities and lack of proper interconnections between the systems of the larger producing companies. The annual output capacity of this excess power is equivalent to about 668,500 barrels of fuel oil. In addition to the unavailable actual excess capacity in hydroelectric plants of the individual companies operating in this state, the failure to take advantage of the diversity between the system peak loads of these various companies and the inability at the present time to utilize fully the stream flow at the separate plants because of the lack of interconnections between the individual transmission systems, represent a waste of electric energy, which is equivalent to not less than 1,100,000 barrels of fuel oil annually. Adequate and proper interconnections between the larger independent transmission systems would remedy this situation.

The present installed capacity of public utility and industrial steam power plants in the five Pacific Coast states hereinbefore mentioned is about 1,729,600 horsepower, of which total approximately 804,900 horsepower is installed in California.

The present fuel oil consumption of these steam power plants is at the rate of about 9,770,000 barrels per year, of which amount some 3,950,000 barrels are consumed in California outside of the oil fields.

This information in shown in Table 32.

TABLE 32.

Steam Plant Installation in Pacific Coast States, Public Utilities and Industrial Establishments, in Horsepower.

Installed capacity	California	Oregon	Washington	Nevada	Arizona	Totals
1902	220,937	59,404	140,110	1,156	16,498	438,105
1907	397,986	114,132	263,016	3,392	34,973	813.499
1912	664,987	196,112	393,276	8,808	56,787	1,319,970
1917 (estimated)	804,900	267,800	522,000	22,400	112,500	1,729,600

Railroads at the present time consume approximately 33,996,000 barrels of California fuel oil per annum, of which amount about 24,-790,000 barrels are consumed by railroads in California and other Pacific Coast states.

In addition to the plants consuming California fuel oil, stationary internal combustion engines are relatively larger users of gasoline and distillates. The capacity of these engines installed in manufacturing

establishments in the five Pacific Coast states is at the present time approximately 17,980 horsepower. These installations have decreased continuously during the last ten years, as shown in Table 33.

TABLE 33.

Gas and Oil Engine Installations in Pacific Coast States, Public Utilities and Industrial Establishments, in Horsepower.

Installed capacity	California	Oregon	Washington	Nevada	Arizona	Totals
1902	10,111	475	1,218	262	2,120	14,186
1907	27,788	677	1,776	965	1,833	33,039
1912	13,832	906	1,764	1,266	1,115	18.883
1917 (estimated)	13,000	1,010	1,750	1,440	780	17,980

While the greatest individual saving in fuel oil would be realized through the electrification of the mountain divisions of steam railroads in California over the Siskiyou, Sierra Nevada, and Tehachapi grades, this is a matter for the future rather than one which can be counted upon to relieve the present situation. Such a comprehensive plan for the substitution of hydroelectric energy for fuel oil could not be carried out immediately and the benefits resulting from such a change would, if immediate steps were taken to begin construction, not be realized for from two and a half to three years. The saving in fuel oil by the electrification of the mountain divisions of the principal railroads would be from 3,200,000 to 3,800,000 barrels per year. The expense involved in making the change would be from $17,500,000 to $20,000,000.

Viewing the matter from a practical standpoint, the only early relief which can be anticipated from a greater use of hydroelectric energy will result from the interconnection of the more important electric transmission systems, thus making usable a larger proportion of the available developed water power. This additional energy if utilized for power purposes, both in the steam plants and those of industrial users of fuel oil, will permit the almost immediate conservation of approximately 1,500,000 barrels of fuel oil per year.

The substitution of electric power for that produced by internal combustion engines accessible to existing electric distribution lines in California would, in all probability, effect an annual saving of about 550,000 barrels of gasoline and engine distillate, but in order to fully accomplish this result it would be necessary to develop considerable additional power, which presumably will not be practicable during the war because of the impossibility of obtaining prompt delivery of electrical equipment and the time required to develop hydroelectric properties.

E. Natural Gas.

We have made inquiry into the extent to which California fuel oil has been conserved by the substitution of natural gas and to the possibility for further conservation of California fuel oil by the same means.

The committee has secured considerable data with reference to the natural gas situation in the various oil fields of California and in particular has had the benefit of a special report on the subject of natural gas submitted by Mr. J. F. McMahon, of the Valley Natural Gas Company, and associates, who made a special investigation, for the purpose of this report, into the conditions prevailing in each petroleum field in California.

Natural gas occurs in the oil fields in two forms, dry gas, which is found alone in the strata containing it, and wet gas, which is associated underground with petroleum and escapes to the surface along with the petroleum. The larger portion of natural gas which reaches a market in California at the present time is wet gas.

California natural gas is utilized partly in the oil fields and partly in various sections of the state to which it is transmitted by pipe lines for sale for domestic and industrial purposes. A 12-inch pipe line, 111 miles in length, having a maximum capacity of 23,000,000 cubic feet daily, conveys natural gas from the Midway field to the city of Los Angeles and surrounding communities. Natural gas from the Whittier-Fullerton field is used in Los Angeles County and in a large number of towns in Orange County. The Santa Maria field supplies natural gas to seven or eight towns, including the city of San Luis Obispo. The Summerland field supplies a small quantity of natural gas for domestic consumption. In Kern County the towns of Maricopa, Taft and Fellows are served with natural gas and a pipe line having a length of 40 miles transports natural gas from the Midway field for domestic and industrial consumption in Bakersfield.

The characteristics of the various California oil fields with reference to natural gas are as follows:

Midway Field.

This field supplies the largest amount of natural gas in California. Included in the field are the Buena Vista Hills, which contain Naval Reserve No. 2, the only large reservoir of dry gas thus far discovered in the California oil fields. The present production from the Buena Vista Hills field is about 90,000,000 cubic feet per day, of which amount about 40,000,000 cubic feet per day is dry gas. This gas has a high heating value and furnishes a large part of the gas distributed by Midway Gas Company and Valley Natural Gas Company. The main body of the Midway-Sunset field supplies approximately 10,000,000 cubic feet of wet gas per day, all of which is used in the field with

the exception of some four or five million feet which are lost. This loss represents a small surplus on many properties, so widely separated that its conservation would not be commercially feasible.

Approximately 20,000,000 cubic feet of natural gas per day is potentially available in addition to that which is now being produced. This gas is principally being produced on lands the title to which is in dispute with the federal government. Mr. McMahon reports that it would cost over $250,000 to install the equipment necessary to take care of the natural gas which is now being wasted from lands involved in government suits and that the oil companies hesitate to make such an investment in face of the possibility that they may hereafter lose the same.

McKittrick Field.

Only a small amount of natural gas is produced in this field. The gas is all used locally, together with about 500 barrels of crude oil daily.

Belridge Field.

Wet gas supplies all the fuel requirements of this field. This is the only field in the state in which no crude oil is burned. In addition to the wet gas in the field, the Belridge Oil Company has a dry gas well, at present closed in, which is reported to be capable of producing 3,000,000 cubic feet per day. Mr. McMahon suggests the possibility of utilizing these 3,000,000 cubic feet per day to replace the 500 barrels of crude oil which are being burned daily at McKittrick.

Lost Hills Field.

This field produces about 2,500,000 cubic feet of gas per day, of which about 1,000,000 cubic feet have been wasting into the air. Compressors for pumping this gas are now being installed. When they are completed approximately one-half of the 250 barrels of crude oil which are daily consumed in this field will be saved.

Kern River Field.

This field produces very little gas, all of which is utilized in the field. About 6,000,000 cubic feet of gas per day are conveyed to this field from the Midway field notwithstanding which fact 1,800 barrels of fuel oil daily are required in this field.

Coalinga Field.

The production of natural gas in this field comes largely from the properties of the Shell Company of California and of Kern Trading and Oil Company, which companies have taken active steps to conserve all the gas which is being produced. Approximately one-half the producing wells in this field are pumped with gas engines. Electric motors are also largely used. Eighteen hundred barrels of crude oil per day are consumed in this field. Electric power may eventually save a considerable portion of this crude oil.

Santa Maria Field.

This field produces a considerable volume of natural gas, all of which is either utilized in the field or for domestic service in Santa Maria, San Luis Obispo and other nearby towns. This field has ample compressor capacity to care for increased quantities of natural gas and excess gas may be transported to the Union Oil Company at Avila, where crude oil is now being burned.

Ventura Field.

Only a small amount of gas is now produced in this field, but the prospects of additional development are bright.

Whittier-Fullerton Field.

This field ranks second in the production of natural gas, being surpassed only by the Midway field. Of the estimated total daily production of 31,250,000 cubic feet, it is estimated that 17,000,000 feet are used in the field, 6,000,000 for higher industrial uses and 3,000,000 for domestic use. The Southern Counties Gas Company distributes natural gas from this field to a number of towns in Orange County and the Midway Gas Company augments its supply from the Midway field with about 8,000,000 cubic feet per day from the properties of the Standard Oil Company. Very little natural gas in this field is allowed to waste into the atmosphere.

Salt Lake Field.

This field produces about 4,600,000 cubic feet of gas daily. One-half of this production is utilized locally for fuel and about one-fourth is distributed in Los Angeles through the mains of the Economic Gas Company.

Table 34 shows the production and distribution of natural gas in California as of June 1, 1917, as reported by Mr. McMahon.

TABLE 34.

Production and Distribution of Natural Gas in California June 1, 1917, as Reported by Mr. J. F. McMahon.

Field	Estimated total available daily production, June 1, 1917 (M. cu. ft.)	Fuel use displacing oil, field developments and operations (M. cu. ft.)	Higher industrial use (M. cu. ft.)	Domestic use (M. cu. ft.)	Lost in transportation, line and field losses (M. cu. ft.)	Surplus held as reserve supply (M. cu. ft.)	Available by installation additional compressors (M. cu. ft.)
Midway-Sunset	100,000	42,000	3,000	17,000	8,000	10,000	20,000
McKittrick	1,000	600	300	100			
Belridge	5,000	1,750	150	100		3,000	
Lost Hills*	2,500	900	400	200			1,000
Kern River	1,500	600	700	200			
Coalinga	9,200	6,000	3,000	200			
Santa Maria	15,650	11,000	3,000	1,650			
Ventura	2,000	1,500	300	200			
Whittier-Fullerton	31,250	17,000	6,000	3,000	1,000	3,000	1,250
Salt Lake	4,600	2,600	500	1,000			500
Totals	172,700	83,950	17,350	23,650	9,000	16,000	22,750

*Remarks: Compressors now being installed.

Reports which we have received from all the oil companies of the state seem to indicate that the consumption of fuel oil in the oil fields is approximately 8,500 barrels daily.

It is doubtful whether more than a small percentage of this remaining oil consumption in the fields may be eliminated by the further use of natural gas. The most feasible possibility of such substitution which seems now to exist is the replacement with gas transported from the Belridge field of the 500 barrels of crude oil daily consumed in the McKittrick field.

We reach the following conclusions with reference to the natural gas situation in California:

1. The production of natural gas has passed the peak and is now gradually declining.

2. With the exception of a few isolated and unimportant instances, further conservation of natural gas in substantial quantities can be accomplished only on the properties which are now involved in litigation with the federal government.

3. If the present rate of consumption of natural gas continues, additional compressor capacity will gradually be required to overcome the diminishing pressures at which the gas will reach the surface.

4. The most effective instrumentality for securing a decrease in oil consumption in the oil fields would seem to be the increased use of electric power and of internal combustion engines and not an increased consumption of natural gas.

IV. *Conclusion.*

On the possibility of decreasing the consumption of California petroleum and its products by the conservation thereof, we reach the following general conclusions:

1. It is the duty of all users of California petroleum and its products to conserve the use thereof by every reasonable means, both during the war and thereafter.

2. As soon as can reasonably be done, consistent with the maintenance of the efficiency of our transportation systems and other industries during the war, the further burning of unrefined petroleum should be prevented, by governmental authority if necessary.

3. Field losses of petroleum in the oil fields have been reduced almost to a negligible amount.

4. The increasing use of internal combustion engines and improved refining processes will gradually bring about a higher and more efficient use of petroleum and its products.

5. Whether the use of gasoline by pleasure automobiles and unnecessary jitneys shall be curtailed or abrogated is a question of national scope, to be decided by the federal government.

6. Mexican fuel oil can be substituted for the greater portion of the 3,000,000 barrels of California fuel oil still sold on the west coast of Central and South America, but further than this can not be substituted for California fuel oil during the war.

7. Coal has recently been substituted for California fuel oil in the Northwest to the extent of 1,000,000 barrels of fuel oil annually and is being substituted and can be further substituted to a limited extent on railroad locomotives operating in the vicinity of the coal fields of Washington, the Rocky Mountain States and New Mexico, but further than this can not be used as a substitute for California fuel oil during the war.

8. Powdered coal is still in an experimental stage so far as railroad locomotives are concerned and can not be looked to as a substitute for California fuel oil during the war.

9. Hydroelectric energy has already been substituted extensively for power derived from California fuel oil and by interconnections between the systems of California hydroelectric companies can conserve fuel oil heretofore used in steam plants of electric companies and be made available to the extent of the surplus now existing. However, by reason

of the time necessary to develop additional hydroelectric plants the time necessary to convert the railroads and other industries to hydroelectric energy and the expense and difficulty of securing material, no substantial saving of California fuel oil by the substitution of hydroelectric energy can be anticipated during the war.

10. Natural gas has presumably reached its maximum production in the California oil fields and can not reasonably be looked to as a further substitute for California fuel oil during the war or thereafter.

11. During the war not materially in excess of 5,000,000 additional barrels of California fuel oil can be conserved annually by the substitution of other forms of fuel or power or by any of the other methods of conservation herein considered. As soon as possible, however, the users of California fuel oil must prepare to turn to other forms of fuel or power.

CHAPTER XII.

CONCLUSIONS AND RECOMMENDATIONS.

In this final chapter, we shall state our conclusions on the facts of the California petroleum industry and shall make such recommendations as seem appropriate.

I. *Conclusions.*

1. Utilization.

Far beyond the borders of California, her petroleum and its products play a vital part in commerce and industry.

California fuel oil operates the Panama Canal; the greater part of the steam railroads of Washington, Oregon, California, Nevada, Utah, Arizona and New Mexico; the steamship lines along the Pacific coast from Mexico to Alaska and across the ocean to Hawaii; the artificial gas plants of California, Oregon, Washington, Nevada, Arizona and Hawaii; the mines and smelters of California, Nevada and Arizona; the cement plants and sugar refineries of California; and a substantial portion of the manufacturing, industrial and agricultural enterprises of the Pacific Coast States of the Union.

California fuel oil supplies the Pacific coast fuel requirements of the United States Navy and Army and of the various state and municipal governments.

Radiating from California, north, west and south, California fuel oil, to a considerable extent, operates the railroads and industries of western Canada; the sugar refineries and railroads of Hawaii; and the railroads, steamship companies, mines and smelters of the west coast of Central and South America.

The products of California petroleum, such as kerosene, gasoline, distillates, lubricants and road oils meet the requirements of Arizona, California, Nevada, Oregon, Washington, Alaska and Hawaii. California kerosene is shipped in enormous quantities to China, Japan, India and Australia and to the western coast of Central and South America. California distillates and lubricants are sold in nearly every important state of the United States, as well as in England, Canada and Australia.

Important as is the part which California petroleum and its products have heretofore played in the industrial life of the nation during times of peace, much more important is the part which the state should play and will play, if possible, in meeting the emergency in the supply of fuel oil, gasoline and lubricants, created by the war.

2. Production.

California produces between one-fourth and one-fifth of the world's supply of petroleum. One-third of the entire supply of the United States is produced in California.

The year of California's greatest production was 1914, in which year 103,620,000 barrels were produced. Production fell in 1915 to 89,570,000 barrels, and increased slightly in 1916 to 91,820,000 barrels.

Notwithstanding the fact that a net average of 52 new wells was added to the producing wells of California during each month from January to May, 1917, inclusive, and the fact that drilling during these months was more active than during any other period in the last three or four years, the daily production was slightly less in May than in January.

Unless the measures hereinafter recommended for increasing production are adopted, it is improbable that the production in 1917 will exceed the 1916 production by more than 2,000,000 barrels, if at all.

From the data available to us, we are convinced that the public can not hope for further substantial increases in California's annual petroleum supply by the discovery of important new fields or of large extensions of existing fields.

3. Consumption.

The consumption of California petroleum in 1916 was 104,930,000 barrels, being more than 13,100,000 barrels greater than the production. The excess was taken from storage.

Consumption in 1916 outran production an average of 1,100,000 barrels per month and 35,650 barrels per day.

During the first five months of 1917, consumption outran production 5,415,000 barrels, being 1,083,000 barrels per month and 35,860 barrels per day.

Due to normal increase in consumption as well as the additional extraordinary requirements of the war which are already being felt, it is doubtful whether consumption in 1917 can be reduced below the consumption of 1916, notwithstanding the substitution of other fuel or power and the further possibilities of conservation pointed out in this report.

Consumers of California petroleum will shortly face a condition of decreasing production and increasing demand. This condition points inevitably to the necessity of developing other sources of fuel or power.

4. Storage.

Crude oil stocks in California have fallen from 57,147,000 barrels on December 31, 1915, to 44,036,000 barrels on December 31, 1916, a reduction during the year of 13,110,000 barrels, or 23 per cent.

Standard Oil Company reports that during the first five months of 1917 the field and pipe line crude oil stocks of all companies were further depleted as follows:

1917	Storage depletion in barrels
January	976,036
February	1,031,960
March	854,333
April	1,197,475
May	1,355,318
Total	5,415,122

The total remaining storage on June 1, 1917, is reported to have been slightly in excess of 38,000,000 barrels.

A portion of the crude oil in storage can not be utilized because it is located below the outlets of tanks and reservoirs or is being used for the operation of oil pipe lines or for other reasons. Of the total stocks on June 1, 1917, not in excess of 32,000,000 barrels were available for use. Of this amount, 12,000,000 barrels were refining oil and would yield approximately 7,000,000 barrels of residuum. On June 1, 1917, there were available from crude oil stocks approximately 27,000,000 barrels for fuel.

If the present excess of consumption over production, amounting to an average of 1,083,000 barrels per month, continues, the entire available storage of California fuel oil will be exhausted by June 1, 1919.

If a margin of safety of 10,000,000 barrels of fuel oil is maintained, and if the present relationship between production and consumption continues, the margin of safety for fuel oil will be reached by September 20, 1918.

If consumption is materially increased, as seems likely, both because of normally increased requirements, as well as the extraordinary requirements of the war, or if production decreases, as seems likely unless the relief herein recommended is given, both the margin of safety and the complete depletion of all California stocks will be reached considerably prior to the dates indicated.

The principal railroads of California, with the exception of the Southern Pacific Company, have made the necessary arrangements to meet their requirements for at least one year.

At the present rate of production by Kern Trading and Oil Company, the Southern Pacific Company's fuel oil bureau, bearing in mind also the purchase of fuel oil by the Southern Pacific Company, including 1,000,000 barrels bought from Union Oil Company and not as yet drawn

on, and bearing in mind also the Southern Pacific Company's consumption of fuel oil, the Kern Trading and Oil Company's storage of fuel oil will be exhausted by December, 1917, unless the recently augmented drilling operations of Kern Trading and Oil Company increases the Southern Pacific Company's production and unless the Southern Pacific Company effects a substantial saving of fuel oil by converting to coal those portions of its system which are located in proximity to the coal fields of Washington, the Rocky Mountain States and New Mexico. If the receipts of fuel oil by the Southern Pacific Company decrease or its consumption increases, the depletion of its stocks will occur before December 1, 1917.

If the Kern Trading and Oil Company's storage should be exhausted, it would be necessary for Southern Pacific Company to enter the market to purchase oil from general stocks in storage, which amounted on June 1, 1917, to slightly over 38,000,000 barrels. These stocks are owned principally by Standard Oil Company and Union Oil Company. If these companies should be unwilling to sell to the railroads fuel oil from their storage, we assume that the federal government would have the right to commandeer the stocks and to compel their delivery for the operation of the railroads as long as the stocks hold out. Such action, if on a large scale, would necessarily deprive other important industries of petroleum and its products.

5. Conservation.

Field losses of petroleum in the California fields have been almost entirely eliminated and the amount of fuel oil used in field drilling and pumping has been largely reduced by the substitution of natural gas and electric energy. The operators are now generally taking steps to reduce the remaining use of approximately 8,500 barrels of fuel oil daily by the installation of jacks and electric motors. The use of fuel oil in the fields for pumping and drilling can not be entirely eliminated.

The principal petroleum refineries of California are working on improved processes of refining. The amount of crude oil which is being refined is increasing and a proportionally larger amount of gasoline and lubricants is also being secured. The result has been a large surplus of kerosene which it has been necessary to export to the Orient, Australia and Central and South America.

Mexican petroleum was substituted early in 1917 for California petroleum amounting to approximately 2,750,000 barrels annually, heretofore sold by Union Oil Company in Chili. A considerable portion of the remaining 3,000,000 barrels of California fuel oil sold in 1916 on the west coast of Central and South America, including the Panama Canal, can likewise be saved by the substitution of Mexican petroleum from the fields of Tampico and Tuxpam. By reason principally of

transportation difficulties, Mexican petroleum will not be available, during the war, as a further substitute for more than 3 per cent of California petroleum. After the termination of the war and the resumption of normal transportation conditions, we may assume that Mexican petroleum will play an important part in the commerce and industry of a considerable portion of the Pacific coasts of North, Central and South America.

Coal can not be substituted for California fuel oil to any substantial extent during the war because of present difficulties in the production and transportation of coal. Approximately 1,000,000 barrels of California fuel oil will be saved in the ensuing year in the Northwest by the substitution of coal for California fuel oil by the Oregon Short Line and other industries. The Los Angeles and Salt Lake Railroad Company and The Western Pacific Railroad Company are converting a portion of their systems in Utah and Nevada from California fuel oil to coal produced in the Rocky Mountain States. The Southern Pacific Company and The Atchison, Topeka and Santa Fe Railway Company can also gradually convert from fuel oil to coal those portions of their systems which are in proximity to the coal fields of the Northwest, the Rocky Mountain States and New Mexico. Apart from what has already been accomplished and the further possibilities herein indicated, there is little possibility of further conversion from California fuel oil to coal during the war, unless the conditions surrounding the production and transportation of coal materially change.

Powdered coal has been successfully used in cement plants, stationary boilers or power plants and metallurgical furnaces. One cement plant in the Northwest has recently converted its plant from California fuel oil to powdered coal, resulting in a saving of 84,000 barrels of California fuel oil annually. Apart from a possible slight additional saving in the Northwest, it is not reasonable to expect that powdered coal will be further substituted for California fuel oil during the war.

Hydroelectric energy has already been substituted to a considerable extent for California fuel oil in industrial and agricultural uses, but the difficulty in securing copper and other material and the disturbance of existing conditions are such that large additional savings of California fuel oil by the substitution of hydroelectric energy can not be anticipated during the war. A small saving of California fuel oil can be effected, during the war, by the further substitution of electric motors for fuel oil in the California oil fields and by such interconnection between the systems of various electric companies as will eliminate or reduce the necessity of maintaining steam electric plants. After the termination of the war and the restoration of normal industrial conditions, we may expect that hydroelectric energy will play an increasingly

important part as a substitute for fuel oil in all the Pacific Coast States in which such energy is available.

Natural gas has already been substituted to almost the entire extent of its supply, for fuel oil in the California petroleum fields, and for fuel oil and artificial gas for higher industrial and domestic uses. The maximum production of natural gas in the California petroleum fields has been reached and will shortly decline so that it is not to be anticipated that natural gas will, to any substantial extent, further replace other forms of fuel.

We conclude that during the war some further saving of California fuel oil is possible by elimination of losses and substitution of other forms of fuel or power, but that no large saving can be effected without very serious impairment to the efficiency of the transportation systems and industries of the Pacific coast.

The great importance of gasoline and lubricants must be recognized and steps should be taken as soon as reasonably possible to the end that no more unrefined petroleum is burned by any railroad company or other industry. No part of California petroleum should be thus burned except the residuum left after refining.

If a sufficient amount of fuel oil can not be secured from Mexico after the war, the railroads and other industries of the Pacific coast must gradually make arrangements to use other forms of energy, such as hydroelectric energy or powdered coal.

6. The Remedy.

The remedy which imperatively presents itself in view of the emergency created by the war is the prompt and substantial increase in the production of California petroleum.

While we do not desire to minimize the results which can be accomplished and should be accomplished by the further diminution of field losses, the higher use of petroleum and its products and the substitution of other forms of fuel or power, during the war as well as thereafter, the cardinal fact remains that the only means which will be effective in a large way to meet the present emergency is a prompt, substantial increase in production.

We estimate that this increased production should amount to more than 35,000 barrels per day and that such increased production can not reasonably be expected before June 1, 1918.

Each difficulty standing in the way of prompt and substantial increased production must be quickly solved, if the increase is to forestall a serious industrial crisis.

7. Increased Production—Material.

The necessary increased production can not be secured unless large additional amounts of oil well casing, drill stem pipe and other oil well material are promptly brought into California.

The oil well supply houses report that they can fill no orders for complete drilling outfits in addition to those already taken.

The larger oil companies have on hand or have heretofore placed orders for enough material to complete their 1917 drilling operations as heretofore planned, but no material for additional drilling beyond such plans. Many small operators report that they would drill if they could secure the necessary material, but that it has been impossible for them to secure such material, even at the high prices now prevailing.

Receiver Payne reports that he is willing to drill, if authorized by the federal court, but that he does not know where he could secure the necessary material unless the federal government should take the necessary steps to assist the California producers.

In our opinion, the only way to meet the situation, in view of the existing conditions, is to have the federal government direct the manufacturers of oil well supplies to devote sufficient capacity of their plants to supply the requirements of oil producers in California and other sections of the United States and to direct the railroads to transport such supplies promptly.

8. Increased Production—Labor.

Over 80 per cent of the laborers who are employed in the oil fields and refineries are skilled men, most of whom it would be difficult to replace. If any considerable number of these men are taken from their present employment it will be impossible to increase the production of petroleum in California and difficult even to maintain the present production.

About 3 per cent of these men have already left their employment and have volunteered for service in the various branches of the Army and Navy. About 32 per cent of these employees have registered for the draft.

We suggest the advisability of drawing this situation to the attention of the federal government.

9. Increased Production—The Land.

In order to secure an increase of 35,000 barrels per day in the production of California petroleum, drilling must be done on the land which will yield the largest production in the shortest time by the expenditure of the smallest amount of drilling material and labor.

In Chapter X of this report we have presented the salient facts regarding the productivity of the petroleum lands of the state, together with our conclusions as to where the land most available for prompt increased production is located. We conclude that such lands are located in order of productivity with due regard to time and economy of drilling material in (1) the Buena Vista Hills (Midway field), (2) the

Coyote Hills and La Merced fields (Whittier-Fullerton field), (3) the Sunset field, and (4) the East Coalinga field.

Of the most desirable undrilled lands, approximately 70 per cent are involved in litigation with the federal government. Nearly one-half of the best undrilled proved petroleum lands of the state are claimed by Kern Trading and Oil Company, the fuel oil bureau of the Southern Pacific Company, under patents heretofore issued to Southern Pacific Railroad Company. Of the remaining lands in litigation, a part of the most productive undrilled land is in the possession of Howard M. Payne, federal receiver.

The most promising land in the Coyote Hills and La Merced fields is owned by Standard Oil Company and partly by Union Oil Company. This land is not involved in litigation. The wells in this district, however, are much deeper than in the Midway field and the limits of the productive territory have not as yet been thoroughly proved.

The desirable Buena Vista Hills lands are practically all located in Naval Reserve No. 2. A considerable area, however, of presumably productive undrilled proved land, which in our judgment should be promptly and intensively drilled, is located in the Sunset field and in the east Coalinga field. The larger portion of these lands is claimed by Kern Trading and Oil Company. A portion of them, situated in the Sunset field, is in the possession of the federal receiver. These latter lands, in our judgment, should be promptly drilled, not merely because of the large production which can presumably be secured therefrom, but also because water is known to be encroaching on them and probably will ruin them in large measure unless they are promptly drilled.

The oil companies which own undisputed patented lands of presumed heavy productivity are under a grave responsibility to increase production in the present emergency. With the possible exception of one of the large companies, we are of the opinion that these oil companies are striving earnestly to meet this responsibility. Some operators are drilling wells which entail the expenditure of large amounts of material and labor for a relatively small production.

A review of the situation shows that the present emergency can not be met without the assistance of the federal government.

We shall not undertake to pass judgment on the broad questions of governmental policy which might be affected by further intensive drilling in Naval Reserve No. 2. These questions must be left to the wisdom and the justice of the federal government when the government is in possession of all the facts, among which facts should be included the past and present drilling operations which have been and are now being carried on in this reserve, the effect of such drilling on the amount

and availability of the remaining oil content of the reserve, the productivity and availability of the lands in the reserve as compared with all other oil lands in the state, and the extent of the present emergency as contrasted with the possible future needs of the nation.

We desire, however, to direct attention emphatically to the fact that a considerable portion of proved productive territory, hitherto undrilled, is located outside of the naval reserves; that further development of most of this land has been stopped by litigation with the federal government; that the policy of the federal government which has resulted in the creation of Naval Reserves Nos. 1 and 2 can have no possible application to these lands which are not claimed or needed for the Navy, and that with the help of the federal government substantially increased production can be secured from these lands.

We desire, further, to draw attention to the fact that unless the federal government can bring about most radical changes in the supply of drilling material, the transportation of petroleum and the development of the land, the increased production of over 30,000 barrels per day, which in our judgment is necessary, can not be secured without some additional drilling in Naval Reserve No. 2.

After a careful review of the entire situation and conferences with all interested parties, we have reached the following conclusions with reference to production on the lands now in litigation outside of the naval reserves:

(1) As to the lands not in the possession of the federal receiver, being largely lands claimed by Kern Trading and Oil Company (Southern Pacific Company), we conclude that joint action should at once be taken by the federal government and the claimants to such lands to petition the federal court to permit the claimants to drill intensively under some equitable arrangement by which both the federal government and the claimants will be protected, the federal government to be protected as to the value of the petroleum extracted in case the government should win the litigation and the claimants to be protected to the extent at least of their expenditures incurred under such stipulations in case they should lose the litigation.

(2) As to the lands in the possession of the federal receiver, we conclude that the receiver should be promptly permitted or directed by the federal court, of which he is an officer, to drill additional wells in such territory as gives promises of substantially increased production. If the authority of the federal congress is necessary to authorize the receiver to use for this purpose funds now in his hands or hereafter acquired, we conclude that the necessary legislation should be speedily enacted.

10. Increased Production—Transportation.

When the conversion of the Standard Oil Company's six-inch pipe line from the Whittier-Fullerton field to the refinery at El Segundo to a ten-inch line has been completed, the oil pipe lines of California, if properly administered and correlated, will be sufficient to take care of the pipe line transportation of such increased production as may reasonably be anticipated.

The legislature of California has declared that oil pipe lines are common carriers and are subject to the jurisdiction of the Railroad Commission. The question whether the oil pipe line statutes are constitutional has been submitted to the Supreme Court of the state of California. If the legislation is sustained, the Railroad Commission will have authority to supervise the oil pipe lines so that they may be operated to their greatest efficiency from the point of view of the entire transportation situation. If the jurisdiction of the Railroad Commission is not sustained, some other means must be provided so that the oil pipe lines may be operated to full efficiency in the present emergency.

A more efficient correlation of the use of oil pipe lines, railroad tank cars and tank steamers would result in the release of a considerable number of railroad tank cars, which are badly needed to serve the industrial needs of California and neighboring states. Standard Oil Company reports that it is 3,500 tank cars short at its refinery at El Segundo and that it is accordingly unable to fill urgent orders from the copper mines of Arizona.

Increased transportation facilities may hereafter become necessary if the oil fields of southern California should be called upon, from their surplus production, to help meet the requirements of central and northern California and other territory.

II. *Recommendations.*

We respectfully submit the following recommendations:

Recommendation No. 1.

Increased Production.

We recommend that every reasonable effort be made to increase the production of California petroleum promptly and that to this end additional drilling be undertaken, as quickly as material and labor are available, on the lands on which the largest additional production can be developed in the least time and with the smallest expenditure of material and labor.

Recommendation No. 2.

Decreased Consumption.

We recommend that every reasonable effort be made, consistent with the maintenance of the efficiency of our transportation systems and industries, to conserve the supply of California petroleum by the diminution of field losses, the higher use of petroleum and its products, and the substitution of other forms of fuel or power.

Recommendation No. 3.

Presentation of Facts to Federal Government.

We recommend that the facts with reference to the California petroleum situation, including specifically the imperative necessity for additional production and the relative productivity of undrilled but proved lands, be presented to the President of the United States and to the appropriate departments of the federal government and that the federal government be respectfully urged to render every assistance which the government can render consistent with the highest public interest.

Recommendation No. 4.

Oil Well Material.

We recommend that the attention of the federal government be respectfully drawn to the advisability of directing the manufacturers of oil well supplies to set aside sufficient capacity of their plants for the production of oil well casing, drill stems, wire cables and other material to supply the reasonable requirements of California and other sections of the United States and of directing the railroads to transport such supplies as expeditiously as is consistent with other urgent requirements.

Recommendation No. 5.

Labor.

We recommend that the attention of the federal government be respectfully drawn to the advisability of exempting from service in the armed forces of the nation all skilled workmen employed in the petroleum industry and of indicating to such workmen that their highest present duty is to assist in the maintenance and development of the petroleum industry.

Recommendation No. 6.

Lands in Litigation Where No Receiver.

We recommend that the federal government be respectfully requested, in those instances in which California petroleum lands now in litigation with the federal government are not in the hands of the federal

receiver, to consent, through the Department of Justice, to stipulations under which the claimants will be permitted to drill such lands intensively under an arrangement by which the federal government, if it ultimately wins the suits, will be protected with reference to the petroleum thus produced, and the operators will be protected, if they lose the suits, out of the proceeds of the petroleum thus produced to the extent of at least their expenditures reasonably and fairly made under the stipulation.

Whether any additional drilling shall be done on lands in Naval Reserve No. 2, is a matter which must be left to the wisdom and fairness of the federal government, when the government has before it all the facts, including the needs of the government, present and future, the extent and the effect of the past and present production in this reserve, the urgent necessity for increased production of California petroleum, the relative productivity and availability of undrilled proved lands, and the fact that on any reasonable assumption an additional production of more than 35,000 barrels per day can not be secured unless some additional drilling is done in Naval Reserve No. 2.

We earnestly recommend, however, that pending a determination as to additional drilling in Naval Reserve No. 2, all other California petroleum lands in litigation be at once thrown open to production under the arrangements herein suggested.

Recommendation No. 7.

Lands in Litigation in Possession of Receiver.

We recommend that the federal government be respectfully requested, in those instances in which California petroleum lands now in litigation with the federal government are in possession of the federal receiver, to take appropriate proceedings, through the Department of Justice, so that the receiver may be authorized or directed to proceed at once to drill intensively such lands as are presumptively productive and particularly the lands which are likely to suffer from the infiltration of water, unless drilled.

If the authority of congress is necessary, we recommend that congress be respectfully requested to enact the necessary legislation.

Recommendation No. 8.

Legislation to Open Petroleum Lands

We recommend that the federal government be respectfully requested to enact promptly legislation by which such lands in the public domain as the federal government may consider wise and consistent with public interest will be opened to petroleum development on terms just and reasonable both to the federal government and to such explorers and

operators as have heretofore proceeded or may hereafter proceed in good faith to the exploration and development of petroleum lands. We suggest that the area of the lands in each instance be sufficiently large to permit efficient operation.

We believe that the establishment of a definite constructive policy in this matter will have a wholesome and stimulating effect on the petroleum industry of California and other states.

Recommendation No. 9.

Transportation.

We recommend that the railroad, steamship, oil pipe line and oil companies of California be authorized and directed to take steps immediately to so correlate their respective transportation facilities as to make most available and efficient every agency employed in the transportation of California petroleum and its products.

Recommendation No. 10.

Ultimate Conservation.

We recommend that as soon as reasonably possible, bearing in mind the paramount necessity of the most efficient operation of our transportation systems and other industries during the emergency created by the war, the further burning of California petroleum, unless it has first been refined, be prevented, the higher use of California petroleum and its products insured, substitute forms of fuel or power developed, and the supply of California petroleum by the most efficient use thereof conserved.

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